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FOOD PREFERENCE OF ERI SILKWORM (*PHILOSAMIA RICINI* HUTT.) (SATURNIIDAE : LEPIDOPTERA)

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(Received 22 May 1983)

Among the four different food plants evaluated for suitability to eri silkworm (*Philosamia ricini* Hutt.) the order of preference is castor (*Ricinus communis* Linn.), kesseru (*Heteropanax fragrans* Seem), tapioca (*Manihot utilissima* Pohl.) and barkesseru (*Ailanthus excelsa*). Number of eggs per laying varies from 395 (castor) to 331 (barkesseru). The hatching percentage is highest on castor (90.0%) and lowest on barkesseru (74.0%). Larval period is shorter (16 days) and larval mortality lower (32.6%) on castor and the corresponding values are 22.75 days and 81.4% respectively on barkesseru. Effective rearing rate is higher on castor (67.4%) and kesseru (64.9%) and lower on tapioca (36.6%) and barkesseru (18.6%). Weight of green cocoon and shell are higher on castor and tapioca than kesseru and barkesseru; the corresponding values (gm) are 2.81 and 0.265 (castor), 2.67 and 0.250 (tapioca), 2.52 and 0.228 (kesseru) and 2.18 and 2.203 (barkesseru).
(*Key words:* Eri silkworm, *P. ricini*, food preference)

INTRODUCTION

Eri silkworm (*Philosamia ricini* Hutt.) is a multivoltine and polyphagous species (HAMPSON, 1892) and primarily reared on castor (FLETCHER, 1912). There are two perennial plants viz., kesseru (*Heteropanax frugrans* Seem) and barkesseru (*Ailanthus excelsa*) growing wild in the hilly tracts and plains of North Eastern Region of India and reported to be suitable for ericulture (SARKAR 1980). Barkesseru and kesseru are reported as primary and secondary host plants respectively without any supporting data (CHOWDHURY, 1982) and hence an attempt was made to study the suitability and food preference of these two host plants along with castor (*Ricinus communis* Linn.) and tapioca (*Manihot utilissima* Pohl.) and reported here.

MATERIALS AND METHODS

Eri silkworms were reared on castor, tapioca, kesseru and barkesseru on identical conditions during four different rearing seasons viz., June-July, July-August, August-September and October–November at Ericulture Extension Centre, Diphu, Karbi, Anglong District. All biological parameters were carefully studied and registered for evaluation and analysis. The dead larvae and pupae were microscopically examined to identify the disease. Data on the following aspects were recorded. 1. Number of eggs per laying; 2. Percentage of hatching of eggs; 3. Incubation period of eggs; and 4. Larval duration; 5. Incidence of diseases like pebrine (protozoan), flacherie (bacterial), grasserie (viral) and muscardine (fungal) and relative susceptibility of the larvae due to different food plants; 6. Percentage of larval mortality; 7. Qualitative characters of the cocoons, and 8. Pattern of moth emergence. Effective rearing rate (ERR) is a reliable index for evaluating the preference of a food plant of a sericigenous insect and the same was calculated by the following formula:

$$\frac{\text{No. of larvae spinning cocoon} \times 100}{\text{No. of larvae brushed}}$$

RESULTS AND DISCUSSION

The results of the characters listed

Table 1. Biological data on the rearing performance of eri silkworm on four different food plants (mean values).

Food plant / Rearing season	No. of eggs/dfl	Egg hatching (%)	Incubation period (days)	Larval period (days)	Larval mortality P	F	G	M	Total (%)	Cocoon quality (% Good	Melted	Double / Nacked	ERR (%)
I. *June July*													
Castor	410	89.1	9	17	20.0	14.3	—	—	34.3	72.0	23.0	5.0	65.7
Kesseru	350	70.4	9	18	14.7	27.0	5.0	—	46.7	70.0	25.0	5.0	53.3
Tapioca	327	69.9	9	21	24.0	50.7	7.5	—	82.2	74.0	23.0	3.0	17.8
Barkesseru	290	42.1	9	25	40.2	43.0	15.0	—	98.2	50.0	10.0	40.0	1.8
II. *July-Aug.*													
Castor	422	92.3	8	16	25.6	11.0	5.0	—	41.6	56.0	44.0	0.0	58.4
Kesseru	407	84.0	8	19	10.0	12.0	2.6	—	24.6	87.0	13.0	0.0	75.4
Tapioca	362	77.8	8	20	30.8	29.0	6.5	—	65.8	61.0	10.0	29.0	34.2
Barkesseru	345	83.3	8	26	28.2	45.0	10.0	—	83.2	54.0	14.0	32.0	16.8
III. *Aug.-Sept.*													
Castor	427	92.0	10	15	11.0	15.3	2.5	—	28.8	96.0	4.0	0.0	71.2
Kesseru	502	72.5	10	19	9.8	14.0	—	—	23.8	86.0	14.0	0.0	76.2
Tapioca	438	71.6	11	18	16.5	26.5	9.6	—	52.6	86.0	9.0	5.0	47.4
Barkesseru	422	88.2	12	18	15.5	40.5	17.0	—	73.0	82.0	10.0	8.0	27.0
IV. *Oct.-Nov.*													
Castor	321	86.7	8	16	7.0	18.8	—	—	25.8	86.0	14.0	0.0	74.2
Kesseru	306	85.7	9	18	12.0	25.0	8.4	—	45.4	75.0	25.0	0.0	54.6
Tapioca	240	88.0	9	18	12.0	30.6	10.5	—	53.1	77.0	21.0	2.0	46.9
Barkesseru	267	82.3	10	22	21.2	41.0	10.0	—	71.2	74.0	5.0	21.0	28.8

Symbols denote: dfl—disease free laying; P—Pebrine; F—Flacherie; G—Grasserie; M—Muscardine fungus; ERR—Effective rearing rate.

from 1 to 6 and 7 to 8 are presented in Tables 1 and 2 respectively and the comparative values provided in Table 3. Of the four host plants studied, castor appears to be the ideal food plant for eri silkworm rearing during all the four seasons. Except incubation period and moth emergence (Tables 1 and 2) the other characters show marked difference due to food plants. The larval period and number of eggs/dfl (disease free laying) vary greatly during the different seasons but such difference due to rearing seasons is uniform in all the four food plants studied. The number of eggs/dfl is high on castor (395/dfl) and kesseru (391/dfl) and lowest on barkesseru (331/dfl), the hatching percentage of eggs is high on castor (90%) whereas on the other three host plants the difference is not marked (Table 3). Larval period is always shortest on castor (15 to 17 days) and highest on barkesseru (18 to 26 days) (Tables 1 & 3) further it is observed that irregular growth

TABLE 2. Cocoon characteristics and results of grainage operations.

Food plant Season		Moth emergence (%)	Total number of laying obtained from 100 moths	DFL (%)	Green cocoon weight (gm)	Shell weight (gm)
Castor	I	57.0	24	65.7	2.94	0.28
	II	54.0	23	58.4	2.60	0.24
	III	65.0	30	71.2	2.71	0.25
	IV	68.5	31	74.2	3.00	0.29
	—	61.1	27.00	67.4	2.81	0.265
Kesseru	I	60.0	26	53.3	2.45	0.22
	II	59.5	19	75.4	2.28	0.20
	III	62.5	30	76.2	2.60	0.24
	IV	60.0	30	54.6	2.75	0.25
	—	60.5	26.25	64.9	2.52	0.228
Tapioca	I	58.0	17	17.8	2.61	0.24
	II	52.0	19	34.2	2.50	0.23
	III	60.5	24	47.4	2.67	0.26
	IV	61.0	26	46.9	2.90	0.27
	—	57.9	21.50	36.6	2.67	0.250
Barkesseru	I	45.0	14	1.8	2.00	0.19
	II	39.5	10	16.8	2.05	0.19
	III	41.5	19	27.0	2.26	0.2[illegible]
	IV	43.0	17	28.8	2.40	0.23
	—	42.2	15.00	18.6	2.18	0.203

* Seasons I to IV refer to the period mentioned in Table 1.

TABLE 3. Comparative rearing results on four different food plants.

Character observed	Castor	Kesseru	Tapioca	Barkesseru
No. of eggs/dfl	395	391	342	331
Egg hatching (%)	90.0	78.0	77.0	74.0
Larval period (days)	16.0	18.5	19.25	22.75
Larval mortality (%)	32.6	35.1	63.4	81.4
Good cocoons (%)	77.5	79.5	74.5	65.0
Effective rearing rate (%)	67.4	64.9	36.6	18.6

and moulting problems are on the higher ranges when the larvae feed on barkesseru and become susceptible to diseases and hence larval mortality due to diseases is recorded highest (71.2% to 98.2%) on barkesseru and lowest on castor (32.6%) and kesseru (35.1%). It is also reported that muscardine fungus does not cause larval mortality but the common diseases are bacterial (flacherie) and protozoan (pebrine) while viral disease (grasserie) causes least damage to ericulture (Table 1). Qualitative characters of cocoons indicate poor quality of cocoon and also double cocoon and naked pupae to be more common when the larvae feed on barkesseru (Table 1). Effective rearing rate is higher on castor (67.4%) and kesseru (64.9%) and lower on tapioca (36.6%) and barkesseru (18.6%). JOSHI (1981) while studying the nutritional value of castor and tapioca for ericulture recorded higher concentration of proteins, fats, phosphorous and potassium on castor than on tapioca leaves and concluded castor as the most suitable food plant for ericulture. Rearing on tapioca recorded higher weights of green cocoon (with pupa) and shell (without pupa) than kesseru (Table 2) but registered very low effective rearing rate, higher mortality due to diseases and little prolonged larval stages than kesseru (Table 3) and hence kesseru is considered more suitable food plant for eri silkworm than tapioca. Barkesseru, though useful as a food plant for eri silkworm rearing is not an ideal food plant in view of prolonged larval duration, higher mortality rate due to diseases, poor quality of cocoon produced and low effective rearing rate. Larval duration, larval mortality, effective rearing rate and qualitative characters of cocoon are considered as good indices to assess the suitability of food plant for silkworm. The suitability of the food plants for eri silkworm rearing therefore is in the following order viz., castor, kesseru, tapioca and barkesseru. Further it is concluded here that among the two perennial food plants kesseru is more suitable than barkesseru for eri silkworm rearing and the earlier report of barkesseru as primary and kesseru as secondary food plant (CHOWDHURY, 1982) for eri silkworm rearing appear to be without any data and incorrect. During an extensive survey of eri silkworm rearing in Assam, Meghalaya and Arunachal Pradesh it is found that more than 50% of the rearers use kesseru leaves and less than 5% of the rearers use barkesseru

leaves for ericulture and other rearers use castor. tapioca, payam *(Evodia flaxinifolia)* and korha *(Sapium eugenifolium)* the last two food plants are used very sparingly, only when other leaves are not available.

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BIOLOGY AND SEASONAL INCIDENCE OF *PALEXORISTA SOLENNIS* (DIPTERA : TACHINIDAE) IN SOUTH INDIA

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(*Received 13 November 1982*)

Study of the life history of *Palexorista solennis* (Walker) revealed that the incubation period was 3.8 hr, larval period 4.8 days, pupal period 7.26 days and total life cycle from egg to emergence of adult, was 11.5 days. Although several eggs were laid on each host, only one maggot, occasionally two, completed development. The pre-oviposition or gestation period was 6.9 days. The female laid on an average, 196.4 eggs over a period of 5 days. The peak activity of the parasite was between November and January. *P. solennis* appears to be a promising biological agent for the control of the cabbage leaf webber, *Crocidolomia binotalis* Zeller.

(*Key words: Palexorista solennis*, biology)

INTRODUCTION

The cabbage leaf webber, *Crocidolomia binotalis* Zeller (Lepidoptera: Pyralidae), is a serious pest of cruciferous crops known to cause substantial yield losses during its peak period of activity from November to February. Although chemical control is effective, total reliance on it would be rather injudicious in the long run. Hence, utilization of indigenous parasites to suppress injurious insect populations is an approach to insect control which continues to be of considerable interest. Among the natural biological control agents operating on this pest, the tachinid parasite, *Palexorista solennis* (Walker) was found to exercise considerable restraint on its activity.

To examine the possibilities of utilizing this tachinid for the biological control of the cabbage leaf webber, studies on its biology, rearing technique and seasonal incidence were carried out during the present investigation.

MATERIALS AND METHODS

Throughout the study, the laboratory temperature was 26±2°C and R H was 65 ± 5%. Field collected, mated females were used to start the nucleus culture by exposing fourth instar host larvae to them and rearing the parasitised larvae on cabbage larvae to emergence of the tachinid puparia. The puparia were placed in emergence cages (wooden boxes enclosed on all sides except for two holes on one side to which specimen tubes were fixed) and the adults that emerged were transferred to rearing cages. These were wooden cages, measuring 15 × 7.50 × 20cm provided with glass fronts and muslin cloth on sides. On one side there was a circular hole to which a sleeve was attached to permit easy collection and release of adults. Cotton swabs dipped in 20% honey solution and sugar cubes placed in a small plastic container were used for feeding the parasites. A rubber sponge piece to fit the bottom of the cage was placed inside and moistened periodically to provide sufficient humidity.

Observations on mating habits, pre-oviposition period and fecundity were made as follows: To study the preference for mating, freshly emerged females were provided with males of different ages. The preoviposition

period was determined by providing fourth instar host larvae daily to the mated female until it oviposited on it. Fecundity was determined by counting the number of eggs a female laid on the host exposed to it daily until it died.

The seasonal incidence of *P. solennis* parasitic on *C. binotalis* on cabbage was estimated by collecting samples of fourth instar and prepupal stages of the pest and rearing them separately in specimen tubes in the laboratory. This study was made from October 1977 to September 1978.

RESULTS AND DISCUSSION

Mating habits: Males emerged earlier than females and freshly emerged females preferred to mate with one day-old males. When the male became excited in the presence of the female, it moved towards her with vibrating wings. The male mounted the female with a swift movement and grasped her. It then slipped backward and turned the tip of the abdomen forwards, under that of the female and copulated. They remained in copula for 15 to 70 min (average 26.7 min). Mating was stimulated when the pair was exposed alternately to sunlight and shade RAO (1964) reported that *Palexorista munda* (Wiedemann) *(Drino munda)* mated successfully in the laboratory without exposure to sunlight. Mating could further be induced if after exposing to sunlight, the specimen tube containing the male and female pair was taken in shade and gently tapped on the palm of the hand.

Pre-oviposition period: When a fourth instar larva of *C. binotalis* was provided daily to a mated female enclosed in a rearing cage and fed on 20% honey solution, it did not oviposit on the host larva until the 6th or 7th day. The average pre-oviposition period was 6.9 days.

Oviposition: After the pre-oviposition period, the mated female became restless in the cage, which was a definite sign

TABLE 1. Life history of *Palexorista solennis* (Walker) on *Crocidolomia binotalis* Zeller.

Stages	No. of insects observed	Minimum	Maximum	Average
Egg				
Fecundity	(n = 25)	81.0	259.0	196.4
Incubation period (in hr)	(n = 50)	1.0	8.0	3.8
Larva				
Total larval period (in days)	(n = 50)	4.0	7.0	4.8
Pupa				
Pupal period (in days)	(n = 50)	6.00	8.00	7.26
Adult				
Adult longevity (in days)	(n = 25)	4.00	26.00	17.00
Gestation period (in days)	(n = 25)	6.00	7.00	6.90
Mating period (in min)	(n = 25)	15.00	70.00	26.70

of its maturity. When a host larva was exposed to the female, it moved towards the larva immediately, paused for a while near the head and deposited an egg. The egg was swiftly stuck to any part of the body, but mainly in the inter-segmental regions on the lateral or ventral side. For oviposition, the fly straightened its legs and raised the thorax and head slightly, then turning its abdominal tip, ventrad, forward, protruded the ovipositor to touch the body of the larva.

Egg: The eggs are white and elliptical. Since a major part of the embryonic development was completed inside the parent body, hatching usually took place within 1 to 8 hr (average 3.8 hr). Uterine incubation was not observed in any case. Fourth instar and pre-pupal stages of the host larvae were the most preferred for oviposition, although occasionally third instar larvae were accepted for oviposition. The first and second instar host larvae were completely ignored by the parasite. The female was also observed sponging on the excrement of of the host larva.

The oviposition period ranged from 1 to 5 days during which time the number of eggs laid ranged from 81 to 259 (average: 196.4).

Maggot: The parasitized larvae were reared on cabbage leaves until the fully developed parasite maggot emerged and pupated. None of the parasitized host larvae pupated. In an experiment to study the number of maggots that could be reared from each host, it was found that generally, only one maggot and occasionally two, emerged from a host larva. However, when parasitised larvae were dissected, two to three maggots were found within body of the host. The total larval development period of the parasite from hatching of egg to pupation, ranged from 4 to 7 days with an average of 4.8 days.

Puparium: The maggot left the host soon after the host died, moved away and pupated by attaching itself to the leaf surface. The pupa is coarctate with the skin of the last larval instar hardening and forming the outer shell or puparium which encloses the pupa. The pupal period recorded for 200 puparia, ranged from 6 to 8 days with an average of 7.26 days.

Sex-ratio: The sex-ratio, based on adults that emerged from laboratoty reared puparia, revealed that the males and females were in equal proportion. As in many other tachinids, the female is distinguished from the male by the presence of two proclinate fronto-orbital bristles which are absent in males.

Longevity: Adults, when fed on sugar cubes and 20% honey solution, lived for 4 to 26 days (average : 17 days)

Seasonol incidence

The pest occurred throughout the year, although its intensity varied considerably with the season. However, the maximum parasite activity was restricted to the winter months (November-February) which incidentally coincided with the peak period of activity of the pest. The rate of parasitism recorded in December (34.0%) and January (27.5%) was high, while that of October, November, Februaray and March was 22.0, 29.3, 16.1 and 9.0% respectively. The tachinid appears to be inactive during the other months of the year as no parasitism was recorded from April to September.

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BIOLOGY OF *ELASMUS CLARIPENNIS* CAM. (ELASMIDAE : HYMENOPTERA), AN ECTOPARASITOID OF THE LAC PREDATOR, *EUBLEMMA AMABILIS* MOORE (NOCTUIDAE : LEPIDOPTERA)

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Elasmus claripennis Cam. appears to be a potential biotic agent in the natural control of the most serious lac predator, *Eublemma amabilis* Moore, since it has a short life cycle (11—20 days in summer and rainy season and 20—32 days in winter), a favourable female ratio (84.3%); moderately high fecundity (on an average 28.4, and a maximum of 118 eggs/female); a long adult life (approx. 26 days for female and 8 days for males); and has activity which is well synchronized with that of the host, has no hyperparasites and above all parasitizes the host larvae in their early instars. Description of various stages, mode of oviposition and other bionomical features have been briefly described.

(Key words: ectoparasitoid, *Elasmus claripennis* Cam., lac predator, *Eublemma amabilis* Moore)

INTRODUCTION

The genus *Elasmus* is generally distributed throughout the world. Its economic importance and that of the species *claripennis* has already been highlighted (MALHOTRA & MISHRA, 1971). VARSHNEY (1976) collected fragmentary literature on it and also quoted its records from China and Thailand, but missed the one from Malaya (MILLER, 1933). Since it parasitizes caterpillars of the most destructive lac predator namely, *Eublemma amabilis* Moore, detailed studies on its biology were taken up.

MATERIAL AND METHODS

Healthy, field collected larvae of *E. amabilis* were supplied with fine bits of lac resin in petridishes (6.6 cm and 5.0 cm). By the following day when the larvae had spun a covering made of silk, with frass and lac bits around them, they were exposed to two pairs of parasites for oviposition. The hosts thereafter were examined daily by slightly disturbing a portion of their covering and the parasitised larvae sorted out for observations on post-embryonic development. The same set of parasites could be offered to a fresh batch of hosts for further oviposition. During the study the laboratory temperature ranged from 15.5 to 30.2°C whereas relative humidity from 48.1 to 67.0%.

OBSERVATIONS

Life history:

Egg: The freshly laid egg is translucent, cylindrical, slightly curved in the middle, gradually tapering to a rounded end posteriorly. The average incubation period lasts for 18—24 hr.

Larvae:

First instar: On an average it measures 0.43 mm (range 0.39 mm to 0.46 mm)

in length, width of the head capsule is 0.06 mm. It is cylindrical and transparent. There are four pairs of spiracles, each pair situated on mesothorax and first three abdominal segments. The antennae are very close to the facial mask and raised like two papillae. The mandibles are slightly sclerotized, minute, more or less comma shaped with broad blades which taper to a point, and remain apposed on each other horizontally at rest. This instar lasts for about 30 hr.

Second instar: The second instar larva resembles closely the first one in all respects except that its mandibles are broader basally. On an average the larva measures 0.76 mm (range 0.72 mm to 0.79 mm) in length, the average width of the head capsule being 0.13 mm. This instar lasts for about 18 hr.

Third instar: It can easily be distinguished from the previous instars by the presence of the full complement of nine spiracles, i. e., a pair situated on each of the second to the tenth abdominal segment. The mandibles are comparatively less sclerotized. On an average it measures 1.22 mm in length (range 0.99 mm to 1.38 mm). The average width of the head capsule is 0.19 mm. This instar lasts for about 12 hr.

Fourth instar: It resembles the third instar in all its morphological details, except that the base of the mandibles is much less sclerotised and a pair of ocelli appear on the head. On an average it measures 1.77 mm in length (range 0.65 mm to 2.04 mm). The width of the head capsule is 0.33 mm. This instar lasts for about 60 hr.

Pre-pupa and pupa:

Before pupation the mature larva passes through a prepupal stage which lasts for 20 to 24 hours only. The pupa is broad at the thoracic region and gradually tapers to a point posteriorly. The legs and antennal buds are clearly discernible on the ventral side and those of wings on the dorsolateral side. The pupa is uniformly white in colour and measures on an average 2.32 mm in length. As the time of eclosion approaches the colour of the eyes which is originally white turns to redish, then slightly brownish and finally dark brown. The pupal period varies from 5 to 20 days. The sexes differ considerably in respect to size which on an average is 2.37 mm in males and 3.00 mm in the females. The sexes can easily be distinguished by the presence of an ovipositor in the female, turned ventrally.

Adult:

Oviposition periods: The pre-oviposition, oviposition and post oviposition periods extend on an average to 16.6 (var. 3-30), 11.9 (var. 1-47) and 12.6 (var. 1-64) days respectively.

Mode: The female moves actively over the host galleries to ascertain the position and condition of host larva and finally comes to rest on the third and fourth instar larvae only, in which it inserts the ovipositor through the gallery and pushes it deeper by bending its legs so as to bring itself in contact with the host thereby enabling the ovipositor to penetrate into the host body for egg laying. Thereafter (i. e., when the egg has been laid) the ovipositor is slightly withdrawn from the body of the host although still kept concealed within the gallery for some time, before finally taking it out fully and flying away. Though in majority of the cases the host is stung only once, occurrance of 2 to 10 sting marks on

a host were not uncommon. In the majority of cases the host larva is stung on the porthorax. The parasitised larva becomes lethargic.

Development:

The development of the parasite was studied at room temperature. The newly hatched larva moves about in search of the host and attacks as soon it finds one. The host larva tries to wriggle away but is unable to do so and gets immobilised within 6 to 12 hours from the time of commencement of attack. The parasite remains attached to the host till pupation. The fully fed parasite larva leaves the host and after wandering within the gallery for 12 to 18 hours excretes the meconium, which is brown and is deposited as a beaded string massed haphazardly against the wall of the gallery. Soon after the excretion of meconium the pre-pupal period starts. The last larvel cuticle which is white, slender and thread like remains attached to the pupae.

The eclosion of the adult parasite occurs from the anterior end through a median slit in the pupa and thereafter through the host gallery. The emergence of the adult generally takes place in the afternoon. The total developmental period from egg to adult lasts on an average for 23.4 and 13.8 days (range 14 to 33 and 10 to 18) for males and 23.8 and 15.1 days (range 12 ro 33 and 11 to 20) for females, during winter and summer months respecrively.

Mating:

Mating generally takes place in day time from 10 a m to 2 p m. The average time taken for one mating is 7.32 seconds and one male can mate with a number of females.

Longevity:

On an average the life of the female is 26.2 days and that of the male 8.4 days when allowed to mate but when mating is denied this period is 16.3 and 7.5 days respectively. Thus the life of the female is about three times that of the male when allowed to mate and about twice under unmated condition.

Fecundity:

The average fecundity of the female is 28.4 (range 9 to 118) in about 1 to 21 days. Though the hosts were made readily available, oviposition was not regular since the females do not lay eggs continuously.

Seasonal prevalence: Field observations revealed that the parasite predominates during the months of August/September in *katki* and January/February in *aghani* crop seasons, although comparatively larger numbers are available in the former. Field parasitisation during *katki* '63 and *aghani*' 63—64 crop seasons were 23% and 10.2% respectively and the percentage of females 84.3. MALHOTRA & MISHRA (1971), however, recorded 91 per cent parasitisation during one *katki* season at another locality i. e., Kundri in Palamau district. They further recorded a minimum of 3 and maximum of 10 parasite larvae per host, whereas during the present studies, the minimum was 2 and maximum 20 parasites, the majority of which developed to adults.

DISCUSSION

Although FERRIERE (1929) stated that the utility of this parasite seemed to be restricted since the host caterpillars are attacked only just before pupation, the present studies have revealed that the caterpillars are parasitised from third instar onwards (there being 10 instars

in all). The field parasitisation was to the extent of 23% in one locality and 91% in another. These findings coupled with other attributes of the parasite such as a favourable sex ratio, which is in conformity with the observations of MAHDIHASSAN (1934), a short life cycle, specificity of attack (although the above author suspected some sugarcane borer larvae as its alternative hosts) and absence of hyperparasites, suggest that the parasite apparently has potentialities of being a powerful biotic agent in checking the ravages of this lac predator in the field, although further work on its biology and field incidence in various localities and seasons is considered necessary. The earlier suggestion of MALHORTA & MISHRA (1971) of encouraging this parasite by supplementing food sources of the adults in the field and finding out techniques of mass rearing for field releases also needs urgent attention.

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IMPACT OF ANTENNECTOMY, EYE-BLOCKING AND TIBIAL COATING ON THE FEEDING BEHAVIOUR AND PREDATORY EFFICIENCY OF *RHINOCORIS MARGINATUS* FABR. (REDUVIIDAE : HETEROPTERA)

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Feeding behaviour and predatory efficiency of *Rhinocoris marginatus* was observed on normal (control) and three different sets of experimental bugs viz., antennectomised, eyeblocked and tibia-coated. Comparison of predatory efficiency of normal and that of experimental bugs shows that the antennae play a dominant role in arousal, approach, capture, probing and sucking the prey, Eyes and tibiae are also actively involved in feeding.

(*Key words: Rhinocoris marginatus,* feeding, predatory efficiency, antennectomy, eye blocking, tibial coating)

INTRODUCTION

Rhinocoris marginatus Fabr. is an assasin bug predominantly found in the scrub jungles and semiarid zones of Tamil Nadu. This alate, multivoltine, entomosuccivorous, polyphagous bug is recorded as a potential predator of various insect pests like *Heliothis armigera.* Attempts have been made to employ this bug in the biological control of various insect pests. The bioecology, ecophysiology and ethology of *R. marginatus* have been studied (LIVINGSTONE & AMBROSE, 1978 a; and AMBROSE, 1980). The authors have been studying the feeding behaviour and predatory efficiency of this bug in detail. The present paper is confined to the impact of antennectomy, eye blocking and tibial coating on the predatory efficiency and feeding behaviour.

MATERIALS AND METHODS

Adult insects were collected from Thalai malai, a scrub jungle in between Musiri and Namakkal of Tamil Nadu. They were reared in the laboratory in plastic containers (12×6 cm) on houseflies, camponotine ants and pests of stored grains *Bruchus theobromae*, the insect food being suppplied once a day. This polymorphic species with 3 different morphs viz., niger (black), sanguineous (red) and nigrosanguineous (black and red) shows polymorphic adaptations (AMBROSE, 1980). Red morphs were selected for antennectomy and eye blocking experiments. Tibial coating experiment was performed with black morph.

With the help of fine scissors the antennectomy was performed segmentwise in different categories of insects. Molten paraffin wax was used to seal the cut end of antennae to prevent excessive loss of haemolymph. Eyes were blocked by white and black paints in different experimental sets of insects. Molten wax was used to coat the tibiae. Care was taken to minimize injury when the bugs were subjected to experimentation. The antennectomized, eye blocked and tibial coated insects were allowed to acclimatize for 24 hours. After that the ethology of feeding behaviour and predatory efficiency were observed under the different succeeding acts, viz., arousal – approach – capturing – probing

and sucking, as reported by LIVINGSTONE & AMBROSE (1978a). The predatory efficiency of these experimental bugs was compared with that of the normal bugs and the impact was studied. The black ant *Camponotus compressus* was provided as prey in the experiments.

RESULTS AND DISCUSSION

Antennectomy

Chronological analysis of feeding behaviour and predatory efficiency was observed on four different conditions, viz., a) terminal flagella segment removed from both antennae: b) both flagellar segments removed from both antennae; c) flagellae and pedicels removed from both antennae; and d) whole antennae removed (Table 1).

In the first group, the bugs were observed to be poor in arousal and approach even after seeing the prey, because they took more time for arousal and approach (2 times and 4 times respectively) than those of the normal insects. They were also found to be less efficient in capturing their prey (taking thrice the time of normal insects) and taking 6 times that in the case of the normal insects for sucking the contents of the prey.

When both the flagellae were removed (2nd group) much more delayed arousal and approach responses (4 and 12 times respectively delayed than that of the normal insects) were observed. When compared to those bugs, the normal bugs were found to be 10 times more efficient in capturing and sucking the contents of the prey.

In the third group of bugs, very poor predatory efficiency was observed, with much more delayed arousal (15 times); approach (60 times), capturing (7 times), probing (5 times) and sucking (12 times) responses.

Completely antennectomized group of bugs recorded much more delay in different acts of feeding (Table 1). The observations suggest that the sensory cells in the antennae play a predominant role in arousal, approach, capturing, probing and sucking the prey. The antennectomized insects were found to select their probing sites at random whereas the

TABLE 1. *Rhinocoris marginatus* (red morph) — chronology of feeding acts, in normal and antennectomized (experimental) bugs (Average of six, ± = SE), in minutes.

Condition	Arousal	Approach	Capturing	Probing	Sucking	Total duration
Control	0.116 ±0.05	0.15 ±0.03	1.5 ±0.13	2.5 ±0.89	44.167 ±3.43	48.433 ±5.98
II flagellar segment removed	0.257 ±0.03	0.419 ±0.14	2.75 ±0.52	0.18 ±0.54	45.66 ±2.16	49.266 ±3.39
Both I and II flagellar segment removed	0.556 ±0.15	1.819 ±1.38	9.33 ±3.09	0.45 ±0.1	48.00 ±3.41	60.705 ±8.48
Flagellae and pedicel removed	1.75 ±0.52	9.555 ±1.97	11.417 ±2.06	11.222 ±1.15	73.3 ±3.09	107.244 ±8.79
Whole antennae removed	4.75 ±1.2	11.912 ±0.80	15.83 ±0.6831	9.25 ±0.94	79.58 ±0.08	121.31 ±4.62

TABLE 2. *Rhinocoris marginatus* (red morph)—chronology of feeding acts in normal and eye blocked (experimental) bugs in minutes (Average of six, ± = SE).

Condition		Arousal	Approach	Capturing	Probing	Sucking	Total duration
Control		0.116 ±0.05	0.15 ±0.03	1.5 ±0.13	2.5 ±0.89	44.167 ±3.43	48.433 ±5.98
Right eye alone blocked	White paint	1.583 ±0.58	2.686 ±0.63	1.167 ±0.26	1.167 ±0.02	47.833 ±4.36	54.436 ±5.85
	Black paint	1.75 ±0.52	4.416 ±0.74	1.6 ±.65	6.083 ±1.32	50.16 ±8.52	64.015 ±11.75
Both eyes blocked	White paint	2.5 ±0.35	3.916 ±0.66	4.142 ±0.99	6.75 ±0.52	52.639 ±1.54	69.947 ±4.06
	Black paint	4.0 ±0.35	6.08 ±0.83	6.75 ±0.52	9.64 ±0.79	55.83 ±0.92	82.3 ±3.41

TABLE 3. *Rhinocoris marginatus* (black morph)—chronology of feeding acts in normal and tibial coated bugs (experimental) in minutes (Average of six, ± = SE).

Condition	Arousal	Approach	Capturing	Probing	Sucking	Total duration
Control	0.183 ±0.39	1.333 ±0.52	1.5 ±0.55	2.167 ±0.75	47.00 ±4.73	52.183 ±6.59
Left fore tibia alone coated	0.746 ±0.22	2.833 ±0.75	1.667 ±0.82	2.5 ±0.834	47.167 ±2.79	54.941 ±5.40
Both fore tibiae coated	1.167 ±0.52	4.5 ±0.52	2.5 ±0.55	3.0 ±0.63	51.167 ±0.75	62.166 ±2.86

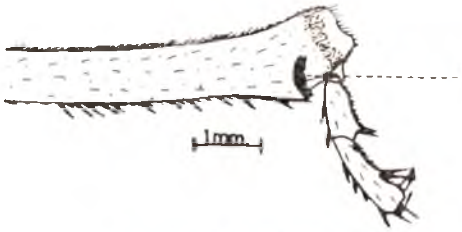
normal insects select the membraneous areas such as the connexivum, junction of head and thorax, thorax and abdomen for sucking the contents of the prey.

Eye blocking

Four groups of insects, each comprising six, were selected for this study. In the first and second groups, only one eye (right eye) was blocked with white and black paint respectively. Similarly both the eyes were blinded in the third and fourth groups with white and black paints respectively.

When the right eye alone was blocked the first and second groups of insects were found to move towards left (Table 2).

When the right eye was blocked with white paint (Group 1) arousal and approach responses were delayed (15 times and 19 times respectively) capturing and probing were not significantly affected in these groups. But the sucking act was considerably delayed (10 times). When the right eye was blocked with black paint (Group 2) the arousal response was similar to that of the first group.



Rhinocoris marginatus tibia.

But the approach act was further delayed (nearly 30 times more than that of the normal bugs). They were also found to probe the insects at random instead of selecting the prospective areas for sucking. So they recorded nearly thrice the probing duration of the normal bugs. Sucking act was also delayed as observed in the first group of insects.

When both the eyes were blocked with white paint (Group 3) these bugs recorded more delayed action in the various feeding acts than the right eye blocked bugs belonging to group 1 and 2. When both the eyes were blocked with black paint (Group 4) the predatory efficiency was lowest and considerably less than that of the bugs belonging to groups 1, 2 and 3.

The above results suggest that vision plays a dominant role in feeding. The comparatively better efficiency in the white painted groups (1 and 3) than in the black painted groups indicates the passage of light through the white paint which consequently provided partial vision. Since the black paint completely blocked the light, the insects were found to prey upon their victims with less efficiency. Similar results were observed in *Acanthaspis pedestris* (LIVINGSTONE & AMBROSE, 1978a).

Tibial pad coating

LIVINGSTONE & AMBROSE (1978a) considered the relative development of the tibial pads as visible indication of predatory efficiency in reduviids. *Rhinocoris marginatus* is devoid of true tibial pads both in the fore and mid legs. But the multiple arrangement of setae in the tibial region and the tibial comb at the tip of the tibia (Fig. 1) facilitate efficient predation as observed in other reduviids (WIGGLESWORTH, 1938; MILLER, 1938, 1942, 1956; EDWARDS, 1962, 1965; LIVINGSTONE & AMBROSE, 1978a, 1982; AMBROSE, 1980).

To ascertain the involvement of tibial setae and tibial comb in the feeding behaviour, the tibiae were coated with molten paraffin wax in two different sets of experimental bugs viz. a) the left fore tibia alone coated; b) both left and right tibiae coated. The feeding behaviour and predatory efficiency of these two sets of bugs were compared with those of the normal ones.

When the left tibia alone was coated, poor predatory efficiency was observed with delayed arousal, approach and capturing responses. When both the tibiae were coated with wax, less predatory efficiency was recorded, indicating the active involvement of tibiae with their multiple arrangement of hairs in feeding (Table 3).

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SOME OBSERVATIONS ON THE BIOLOGY AND HABITS OF ORANGE SHOOT BORER, *OBEREA LATEAPICALIS* PIC. (COLEOPTERA : LAMIIDAE)[1]

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Observations on the biology and habits of the orange shoot borer, *Oberea lateapicalis* Pic. at the Central Horticultural Experiment Station, Chethalli revealed that the beetle was a univoltine, sexually dimorphic insect. Adult beetle emerged out of bored shoot of citrus between second week of April to fourth week of May. Mating commenced 2-3 days after emergence and pairing lasted upto 20—30 minutes. The female inserted eggs singly on the previously girdled tender shoot. The egg hatched in 7 to 11.5 days. The grub stage lasted for 304 to 382 days which included 184—197 feeding days and 120 to 135 days of inactive period i. e., diapause. Before entering into diapause the full-grown grub constructed an air-tight cap at the upper end of bored shoot. The onset of pre-monsoon rain during March resulted in pupation and the adults emerged in 8-12.5 days. The detailed information on the morphological characters of the egg, grub, pupa and adult are given.

(*Key words:* Orange shoot borer, *Oberea lateapicalis*, Lamiidae, diapause, biology)

INTRODUCTION

Among the borer pests of citrus in different parts of the country, orange shoot borer, *Oberea lateapicalis* Pic. was considered to be a minor pest, but recent observations have shown that it is becoming a serious pest of citrus in mixed plantations (citrus + coffee) of Kodagu. ISAHAQUE (1977) recorded *O. pusticata* Gah. on citrus for the first time in Assam. BINAZZI (1974) described the life history and nature of damage of *O. linearis* to forest plants in Tuscany. *O. brevis* Swed. was observed to be a borer pest of soybeans (SINGH & SINGH, 1966: GANGRADE *et al.*, 1971). Some preliminary observations on *O. lateapicalis* were made as early as 1979 (ANONYMOUS, 1979) but the detailed information on the biology and life history of this pest is lacking. An attempt has been made for studying the biology, habits and seasonal incidence of *O. lateapicalis* and the results of the study are presented in this paper.

[1]Contribution No. 240/83 of the Indian Institute of Horticultural Research, 255, Upper Palace Orchards, Sadashivanagar, Post Box No. 8025, Bangalore 560 080.

MATERIAL AND METHODS

Investigations on the life history and habits *O. lateapicalis* were carried out during 1979—1982 at the Central Horticultural Experiment Station, Chethalli. The period of emergence of adults and their feeding habits, mode of copulation and oviposition were studied in borer-infested orchards. The period of adult emergence was determined in 350 plants kept under constant observation throughout the year. The adult habits were studied in the natural abode with the least possible disturbance. The activity of the

young grub from the time of hatching till the commencement of shoot boring were also noted under field conditions. The period of egg laying was studied on 100 healthy newly emerged tagged shoots. The external morphological characters of the egg, grub and pupa were studied by means of a binocular microscope.

RESULTS

Emergence of adults:

After completion of the pupal stage within the bored shoot, the adult beetle cut out the thin cap (constructed by the grub) about 2-3 mm thick at the upper end of the bored shoot and emerged out. The adults started emerging from the second week of April and continued till the fourth week of May (Table 1), the earliest and latest dates of emergence being 8th April and 27th May respectively during the three year study.

TABLE 1. Date of adult emergance of *Oberea lateapicalis* during 1979—1982 at central horti cultural experiment station, Chethalli.

Year	Date of emergence	Period of emergence
1980	April 19	41 days
1981	April 8	50 days
1982	April 23	37 days

Instances of emergence at two extremes were however, very few; maximum emergence was found between the third and fourth week of April. The period of emergence varied from year to year due to the fluctuations in the commencement of pre-monsoon rains.

Sexual dimorphism:

The insect was sexually dimorphic, the females being appreciably larger than the males.

Male: The adult male beetle was 11.5 to 12 00 mm long with 1.5 to 1.7mm width. The length of the ten segmented antennae ranged from 12.0 to 13.5mm.

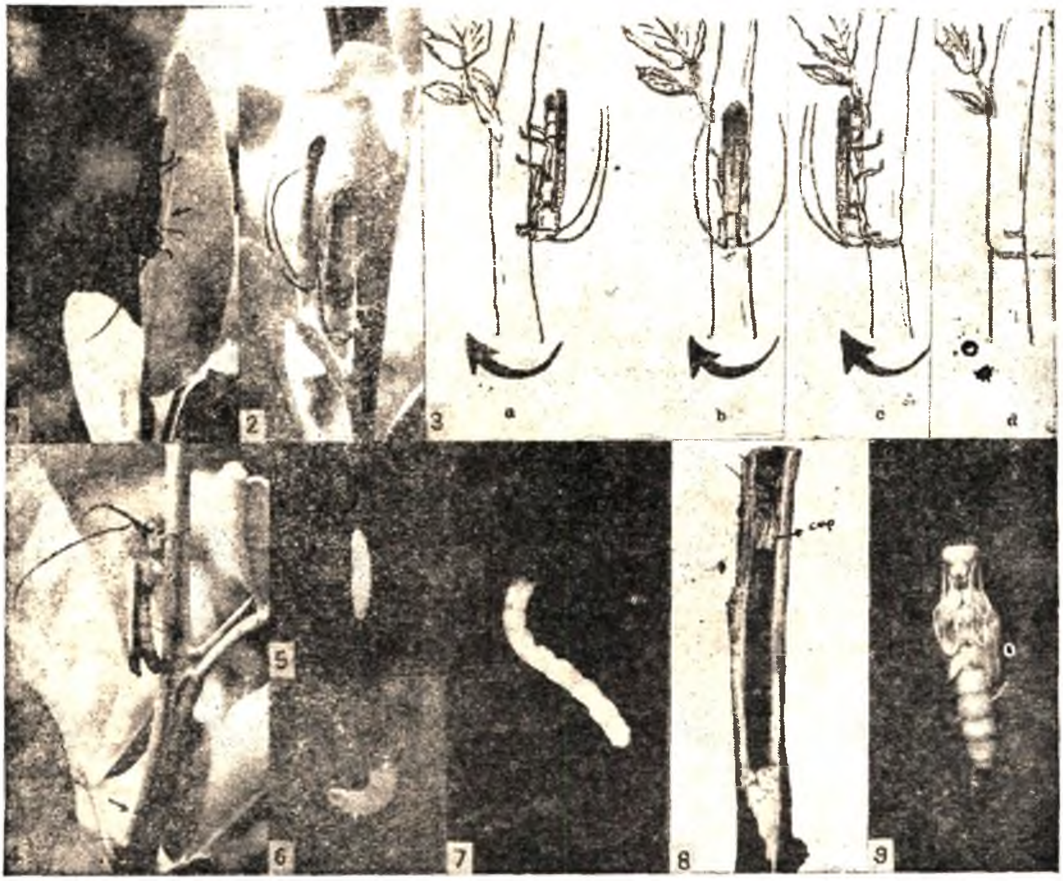
Females: The adult female beetle was 13.0 to 15.0mm long with 1.9 to 2.3 mm width. The length of the ten segmented antennae ranged from 14.0 to 15.2 mm.

Feeding habits of adults:

The feeding habit of this insect was very peculiar. The adult beetle rested upside down on the lower surface of the leaf midrib. It started feeding on the midrib from leaf tip towards the leaf petiole, leaving the leaf margin intact (Fig. 1), a narrow longitudinal slit appeared in due course resulting in characteristic symptom of damage by the adults. They fed mostly during the daytime. The beetle fed both on young and senescent leaves without showing any special preferencc. Sometimes the beetle fed on the bark of the tender shoot.

Locomotion: The adult appeared more dependent on the wings for its flight. The insect did not seem to have firm foot-hold, as it could be easily dislodged by shaking the branches. Immediately after disturbance the adults flew erratically and settled only on newly emerged tender shoots. The flying tract resembled a hyperbolic curve. The fore-wings i. e., elytra were at right angles to the body during flight, when the membranous hind wings were outstretched nearlv parellel to the elytra. Low intensity huming noise was produced by the beetle during flight.

Copulation: The male and female started pairing (Fig. 2), 2—3 days after emergence. Pairing was usually completed before noon on branches and leaves. After a brief period of courtship, the male mounted the female by



Orange shoot borer, *Oberea lateapicalis* Pic.; Fig. 1. Adult feeding on leaf midrib; 2. Male and female in paired condition; 3. The girdling method: a– Beetle sitting upside down to start biting the bark: b– moves in clockwise direction: c– completes half circle: d- shoot ready for egg laying after girdling; e- girdled portion; Fig. 4. Adult female inserting the egg; Fig. 5. Egg; Fig. 6. First instar grub; Fig. 7. Full grown grub; Fig. 8. Airtight cap constructed by the diapausing grub; Fig. 9. Pupa.

grasping the female by its forelegs which were placed in between the middle and hind legs of the female, the middle legs of the male being placed on the central portion of elytra just above third abdominal segments (Fig. 2). The hind legs rested on the elytral end portion. Just prior to copulation, the abdominal tip of male was bent for insertion of the aedeagus. Many a time when the female was girdling the shoot, the male attempted to mount it which resulted in successful copulation. Both female and male remained motionless in the initial stage of copulation; later the female became active in the paired condition carrying the male on its back. The male remained practically static throughout the period. The mating period varied with the period of adult emergence from year to year Thus the adults were observed in paired state as early as the 3rd week of April and upto 2nd week of May.

Oviposition: The female made a preliminary examination of the newly emerged shoot before attempting to lay eggs. During this careful and leisurely inspection which lasted upto 20–30 minutes, the female girdled the newly emerged shoot 4–6 cm below the growing tip before laying eggs. The search for a suitable site for oviposition was not a haphazard one and the female took scrupulous care to check a sizeable shoot before attempting to girdle. The method of girdling was in a particular fashion, the female beetle resting upside down started cutting the bark of the shoot with mandibles in clockwise direction, and it took approximately 20 minutes to complete one circle (Fig. 3). When the girdling was completed the beetle made further search for the egg laying spot. This included a few bitings by the mandibles on the bark of the shoot 2–3 cm above the girdled portion. Then the beetle changed its position by sitting upright and thrusted one egg upwards in the incision made by the mandibles on the bark (Fig. 4). Insertion of the egg took 3 to 6.5 minutes. The beetles bent its abdominal tip which eased the egg deposition. The beetle took on an average 26.5 minutes for girdling and egg laying. After depositing the eggs the beetle again turned upside down and made a few more bitings for 1.5 to 3 minutes with mandibles around the spot where it inserted the egg. The eggs were opaque, light brown and leathery in texture. They were elongate-oval with rounded ends (Fig. 5) and about 2.46 mm long and 0.74 mm wide. On an average eggs hatched in 7 to 11.5 days. The frequency of egg hatching on different days after oviposition is given in Table 2.

Structure and habits of grub and pupa:

The grub: The newly hatched grub (Fig. 6) was creamy white, cylindrical and measured 2.0—2.5 mm in length. The head was dark brown and the rest of the body creamy white. Just after hatching the young grub fed on the egg shell;

TABLE 2. Frequency (days) of hatching of the eggs of *O. [illegible]apicalis*.

7 days	8 days	9 days	10 days	11 days	11.5 days	12 days	Total number of eggs
8	13	3	8	1	1	0	34

then it fed for 12—36 hours on the bark near the egg insersion. Later on it made its way into the central core of the shoot, which was clear from the frass at the point of entry. The grub continued feeding till the end of October. Throughout this period the powdery frass was continuously thrown out and fell on the lower leaves and branches, which helped in detecting the live borer-infested twigs.

The full grown grub (Fig. 7) was soft, fleshy, legless, elongate, cylindrical and 18—30 mm long. It was broader across the abdominal segments measuring 1.54—2.25 mm. The head was sclerotic brownish to blackish, the epicranium being separate from the first thoracic segment. The prothoracic segment was the largest and exceeded the total length of other two thoracic segments taken together. The ten anterior abdominal segments were quite prominent because of their swollen dorsal and ventral lobes, had in common the following structures: the pleural folds of all the thoracic and abdominal segments which were slightly extended and made a continuous band. The tenth abdominal segment had terminal hairs which were not present on other abdominal segments.

The full grown grub constructed an airtight cap (Fig. 8) at the upper end of the bored shoot in the second quarter of November and entered into inactive period i.e., diapause. When the air-tight cap was disturbed the diapausing grub again constructed one more air-tight cap just below the previous cap and again remained inactive. This cap probably protected the grub from the attack of natural enemies. The diapause continued till the commencement of first pre-monsoon shower in the last week of March. Immediately after receipt of rain the diapausing grub pupated. The pupal period lasted for 8—12.5 days with an average of 9.5 days and the adults emerged in time to breed on the spring flush.

Pupa: Initially the pupa was rather glossy white, the eyes and mandibles later become darker. It measured 17.7 to 18.0 mm in length and 4.9 to 5.5 mm in width. The head had the same general appearance as that of the adult but was bent underneath the body. The antennae were placed in a peculiar manner, the first five segments directed backwards dorso-laterally and lying along the body and wing pads, touching the femora of third pair of legs. Part of 5th and 6th antennal segments bent directing the remaining antennal segments forward ventro-laterally and along with tarsal segments of first and second pair of legs. The last antennal segment touched the base of the eye in this condition (Fig. 9). The elytrae extended postero-laterally upto the 4th abdominal segment, their tips lying directly underneath the body. Eight abdominal segments were prominent in pupal stage.

DISCUSSION

Detailed studies on the biology and behaviour of *O. lateapicalis* Pic. were not carried out by earlier workers. However similar studies were made on other species on other crops. For instance SINGH & SINGH (1966) and GANGRADE *et al.* (1971) studied the biology, behaviour and diapause of *Oberea brevis* S. on soybean in Madhya Pradesh. BINAZZI (1974) has given notes on the biology and ethology of *Oberea linearis* L. in Tuscany. The results of all these previous workers on the related borer beetle pests were not comparable with the present

work as the species involved were entirely different.

The sluggish nature of the adults and their characteristic nature of damage on the leaves indicate that the pest is more vulnerable and easier to control at the adult stage than in other stages. Precise information on the adult emergence period and the habits of adults would make the task of adult control much easier for the below mentioned reasons.

(i) To assure against fresh infestation, vigilance against adults is necessary only for 2 months.

(ii) Due to the characteristic nature of feeding the adult beetle can hardly go unnoticed and are detected easily.

(iii) Since the adult beetles are sluggish and do not have firm grip on the plant they can be easily dislodged by shaking the branches and the flying adults can be caught by hand net.

(iv) Synchronising sprays before the ovipositional period will avoid the egg laying and thereby reduce the incidence.

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COMMUNITY STRUCTURE OF SOIL ORIBATIDA AS INFLUENCED BY INDUSTRIAL WASTE WATER

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In the present paper oribatid community of two adjacent sites have been compared. One of the sites was frequently exposed to the industrial waste water, containing many toxic substances. A simplification in the community structure of Oribatida was observed in this site which experienced a reduction in the species number, species richness and species diversity and an increase in the dominance index compared to the other site. A shift in the dominance status for many species have been noted and species were found to be more aggregated in the polluted site. Edaphic and phytosociological studies also indicate that the site in question has undergone ecological degradation.

INTRODUCTION

In view of their immense ecological and economic significance, soil inhabiting oribatids have received much attention compared to other soil inhabiting mites. In India, the composition of soil micro-arthropod community including Oribatida have been studied by SINGH & MUKHARJI (1971), SINGH & PILLAI (1975, 1981), BHATTACHARYA & JOY (1978), BHATTACHARYA *et al.* (1981) and ANANTHA PAI & PRABHOO (1981) under different soil habitats. The present communication deals with the community analysis of soil Oribatida in two contrasting soil habitats, one of which was degraded by industrial effluents. Main objective of such investigation is to assess the extent of anthropogenic influence on natural ecosystem through simplication or otherwise of the community composition of Oribatida. Preliminary findings relating to this has been previously reported by BHATTACHARYA & BHATTACHARYA (1981).

MATERIAL AND METHODS

The present investigation was done at Kalipur Village (23°30'N 87°20'E) near Durgapur Projects Ltd. (DPL). Durgapur, West Bengal. The drain, carrying the effluents from this Coke Oven and Coal Washery plant, contains many toxic substances like ammoniacal nitrogen, phenol, sulphide, cyanide etc. much above the level permissible for discharge (DE et al., 1980). Soil samples were taken from two sites near this drain. First site was very close to the drain and frequently received effluents through the overflowing drain water. This site was considere as 'Polluted site'. The second site was located about 100 meters from this drain but did not receive any effluent as it was located at a higher elevation. This site was considered as 'Unpolluted site'.

During pilot studies, prior to the monthly sampling, some edaphic and phytosociologica

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studies were done. Some routine physico-chemical analysis of the soils of two sites were done following standard methods. An account of these have been published elsewhere (BHATTACHARYA & BHATTACHARYA, 1981). Community structure of plants of both the sites were analysed during pilot survey following MISRA (1968). A complete list of plant species for both the sites was also prepared on the basis of plant materials collected during every sampling occasion.

From each site 12 soil samples of the size of 5 × 5 × 10 cm were taken at monthly intervals for two years at a stretch between January, 1980 to December, 1981 for the analysis of oribatid community. Samples were collected in the first week of each month between 10.00 to 12.00 hours. Oribatid mites, alongwith other actively moving microarthropods, were extracted from the samples by means of a battery of Tullgren funnels. Oribatid community of each site was studied with reference to abundance, relative abundance, frequency and dominance. Dominance of a species was ascertained on the basis of relative abundance following Brockmann-Jerosch scale (cf. TAMURA, 1967) species with relative abundance exceeding 5% were regarded as 'dominants', those between 2–5% as 'subdominants' and remaining species were called 'rare'. Horizontal pattern of microdistribution of the dominant species was worked out with the help of Fischer's coefficient of dispersion (FISCHER, 1960) and further verified by Lloyd's 'mean crowding' (LLOYD, 1967). Additional analysis such as dominance index of McNaughton & Wolf (cf. KARR, 1971), species richness index (MENHINICK, 1964) and species diversity index of Shannon & Weaver (cf. POOLE, 1974), were done for the purpose of comparison and faunal similarity or dissimilarity between the two sites were adjudged using Quotient of Similarity (SORENSEN, 1948).

OBSERVATIONS

Physico-chemical properties of the soils of both the sites recorded during pilot survey as shown in Table 1 reveal that the two sites, in spite of their close proximity, were quite different edaphically. The soil of the polluted site was darker in colour and had increased amount of sand, moisture content, organic carbon and ammoniacal nitrogen. It had distinctly higher water holding capacity and porosity but contained significantly less amount of potassium and total nitrogen. Available phosphate was slightly higher in the polluted site but there was hardly any difference in pH and conductivity of the soils of the two sites.

TABLE 1. Some physico-chemical properties of the soil of the study sites.

Parameters	Polluted site	Unpolluted site
Colour (dry soil)	very dark gray (5Y 3/1)	olive gray (5Y 5/2)
Texture	Loam	Silty clay loam
Mechanical analysis:		
Sand%	35.85	18.47
Silt%	43.24	49.16
Clay%	20.9	32.37
Moisture content*%	39.23	20.4
Water holding capacity %	62.94	48.97
Porosity%	31.85	4.98
Conductivity m. mhos/cm.	0.0005	0.0004
pH	7.73	7.71
Organic carbon %	5.17	2.1
Total nitrogen %	0.17	2.95
Available phosphate (ppm)	2.6	1.8
Potassium (ppm)	17.2	60.0
Ammoniacal nitrogen (ppm)	2.2	1.3

There were 5 species of plants in the polluted site compared to 12 species in the unpolluted site during pilot survey (Tables 2 & 3). Of these, 4 species were common to both the sites. *Cynodon dactylon* had highest importance value in both the sites, but its importance value index (IVI) was considerably higher

in the polluted site. *B. ramosa* and *B. reptans* were next to *Cynodon* in importance values in the unpolluted site but these were totally absent in the polluted site. The plant communities of the two sites were 'moderately dissimilar' as revealed by the Sorensen's quotient of similarity which was 47.1%. A complete list of the plant species of the two sites (Table 4), encountered during the entire period of investigation, revealed that the polluted site had only 10 species of plants (8 monocots and 2 dicots) while 22 species (9 monocots and 13 dicots) were present in the unpolluted site.

TABLE 2. Phytosociological anlysis of the polluted site.

Plant species	F.	D.	R.F.	R.D.	R.Dom.	IVI
Cynodon dactylon	100.0	95.16	40.0	83.97	45.96	169.93
Echinochloa colonum	50.0	12.66	20.0	11.18	23.13	54.31
Croton bonplandianum	16.7	1.5	6.66	1.32	27.15	35 13
Alternathera sp.	66.7	3.83	26.66	3.38	3 7	33.74
Cyperus sp' IV	16.7	0.16	6.66	0.15	0.06	6.87

F. = Frequency, D. = Density, R. F. = Relative Frequency, R. D. = Relative Density, R. Dom. = Relative Dominance, IVI Importance Value Index.

TABLE 3. Phytosociological analysis of the upolluted site.

Plant species	F.	D.	R. F.	R.D.	R.Dom.	IVI
Cynondon dactylon	100.0	35.06	18.75	50.72	23.71	93.18
Brachiaria ramosa	100.0	11.66	18.75	16.83	25.54	61.12
Brachiaria reptans	83.3	11.33	15.62	16.35	11.02	42 99
Alterdanthera sp.	83.3	4.5	15.62	6.49	10.39	32.6
Boerhaavia re pens	16.7	0.16	3.12	0.24	10.8	14.16
Echinochloa eolumnumm	33.3	0.66	6.25	9.96	6.72	13 93
Amaranthus spinosus	16.7	0.33	3.12	0.48	8.7	12.3
Evolvulus nummularius	33.3	1.5	6.25	2.16	0.26	8.67
Chrysopogon aciculatus	16.7	1.5	3.12	2.16	1.66	6.94
Croton bonplandianum	16.7	1.83	3.12	2.64	0.86	6-62
Cyperus sp. III	16.7	0.05	3.12	0.72	0.23	4.07
Sida acuta	16.7	0.16	3.12	0.4	0.07	3.43

(For meaning of symbols refer Table 2)

TABLE 4. List of plant species encountered in the study sites.

Plant species	Polluted site	Unpolluted site
MONOCOT		
Brachiaria ramosa (Linn.) Stapf		+
Brachiaria reptans (Linn.) Gard & C. E. Hubb.	+	+
Carex sp.	+	
Chrysopogon aciculatus Trin.	+	+
Cynodon dactylon Pers.	+	+
Cyperus pumilus Linn.	+	+
Cyperus rotundus Linn.	+	+
Cyperus Sp. III		+
Cyperus Sp. IV	+	
Echinochloa colonum (Linn.) Link	+	+
Perotis indica kuntze		+
DICOT		
Aerva lanata Juss.		+
Alternanthera sp.	+	+
Amaranthus spinosus Linn.		+
Boerhaavia repens Linn.		+
Caadanthera triflora Ham.		+
Commelina benghalensis Linn.		+
Croton bonplandianum Ball.	+	+
Evolvulus nummularius Linn.		+
Lantana camara Linn.		+
Polygonum hydropiper Meissn		+
Rungia pectinata (Linn.) Nees		+
Sida acuta Burm.		+
Solanum nigram Linn,		+

'+' indicates presence of a species

During present investigation a total of 6298 and 5986 oribatid mites were collected from the polluted and the unpolluted sites respectively (Table 5). In both the sites Oribatida was the most common components of the soil microarthropods. It accounted for 41.9% of the total microarthropods and 48:3% of the total acarofauna in the polluted site and constituted 37.7% of the total microarthropods and 51.6% of the total acarofauna in the unpolluted site.

A comparative picture of the abundance of Oribatida along with other groups of Acari microarthropods intoto are shown in Fig. 1. In the polluted site, the abundance of Oribatida was 22.33/sample, whereas it was 21.61/sample in the unpolluted site. Thus the difference in average abundance between the two sites was not significant.

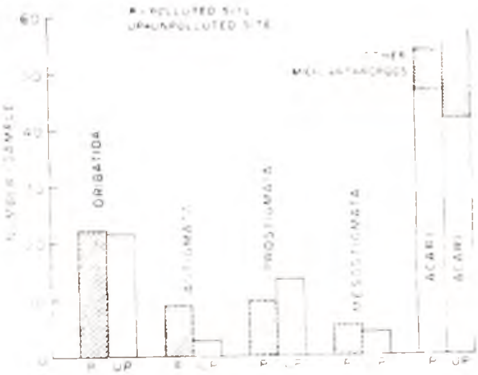

Fig. 1. Comparative picture of abundance of different groups of Acari and microarthropods in toto in the polluted and the unpolluted sites,

Frequency, abundance and relative abundance of oribatid species of both the sites are shown in Table 6. In all 55 species of oribatid mites were collected from the study sites. 33 species of Oribatida were found in the polluted site and 49 species were recorded from the unpolluted site. Thus there was a 32.7% reduction in the number of species. There were 27 species common to both the sites. Out of 49 species recorded in the unpolluted site, 6 species were dominant, 5 were subdominant and 38

TABLE 5. Total number of individuals and relative abundance of Oribatida and other mite groups in the polluted and the unpolluted sites.

Microarthropod groups	Polluted site			Unpolluted site		
	Number	% of Acaro-fauna	% of Microar-thropods	Number	% of Acaro-fauna	% of Microar-toropods
Oribatida	6298	48.8	41.9	5986	51.6	37.7
Astigmata	2532	19.4	16.8	781	6.7	4.9
Prostigmata	2707	20.8	18.0	3695	31.g	23.3
Mesostigmata	1497	11.5	9.9	1130	9.7	7.1
Total acari	13034		86.6	11592		73.1
Other microarthropods	2011		13.4	4263		26.9
Total microarthropods	15045			15855		

TABLE 6. Frequency (F), Abundance (A) and Relative Abundance (RA) of different Oribatid species in the polluted and the unpolluted sites.

Polluted site			Oribatid species	Unpolluted site		
F	A	RA		F	A	RA
			Paleacarus sp.	2.9	0.03	0.15
			Arthroplophora sp.	0.4	0.004	0.02
			Hoplophorella scapellata	10.5	0.14	0.67
8.2	0.16	0.7	*Rhysotritia ardua*	7.9	0.13	0.15
			Eohypochthonius vilhenarum	1.1	0.01	0.05
0.7	0.01	0.03	*Ovochthonius emmae*	4.0	0.05	0.22
0.4	0.003	0.02	*Cosmochthonius lanatus*	0.7	0.01	0.05
0.4	0.003	0.02	*Haplochthonius curvisetosus*			
			Sphaerochthonius sp.	27.1	0.66	3.07 SD
			S. longisetus	5.4	0.06	0.27
			Brachychthonius similis	1.4	0.01	0.07
0.4	0.003	0.02	*Cryptacarus schauenbergi*	22.4	0.43	1.97
			C. dendrisetosus	1.4	0.02	0.08
2.5	0.04	0.17	*Javacarus kuhnelti*			
1.1	0.01	0.06	*Epilohmannia pallida indica*	17.0	0.31	1.45
4.3	0.1	0.46	*E. pallida aegyptica*	33.6	0.7	3.26 SD
0.4	0.003	0.02	*Allonothrus russeolus reticulatus*	2.5	0.03	0.13
			Archagozetes magnus longisetosus	2.4	0.01	0.03

(Contd..)

Table—6 (Contd..)

1	2	3	4	5	6	7
0.7	0.01	0.03	*Malaconothrus peruensis*	1.1	0.01	0.05
0.7	0.01	0.03	*Cyrthermannia ezzati*			
			Gymnodameus sp.	2.2	0.04	0.18
			Berlesezetes auxiliaris	0.4	0.004	0.02
			Eremulus oblongatus	1.1	0.01	0.07
			Maorizetes sp.	0.4	0.004	0.02
0.7	0.01	0.03	*Tectocepheus velatus sarekensis*	26.0	0.55	2.54 SD
0.4	0.01	0.02	*Brachioppiella rajnagari*	0.4	0.004	0.02
1.1	0.01	0.05	*B. variosensillata*	0.4	0.004	0.02
0.7	0.01	0.03	*Lancetoppia confusaria*	15.9	0.35	1.62
			Oppia sp.	1.8	0.04	0.2
1.4	0.01	0.06	*O. raychaudhurii*	10.5	0.23	1.09
1.1	0.01	0.05	*Oxyoppia intermediata*			
10.3	0.23	1.02	*Ramusella (Ramusella)*			
			Chulumaniensis sengbuschi	15.5	0.53	2.46 SD
8.5	0.24	1.06	*Striatoppia lanceolata*	0.7	0.04	0.17
			S. opuntiseta	2.5	0.05	0,27
			S. hammeni	0.4	0.02	0.08
1.4	0.01	0.06	*Strachyoppia* sp.	3.6	0.12	0.57
D42.6	2.92	13.1	*Scapheremaeus polysetosus*	35.7	1.6	7.42 D
D63.1	3.58	16.02	*Scheloribates albialatus*	37.5	1.71	7.92 D
2.8	0.03	0.16	*S. fimbriatoides*	40.1	1.14	4.26 D
D40.1	1.65	7.4	*S. praeincisus interruptus*	59.2	3.03	14.03 D
D50.4	1.61	7.19	*S. elegans*	55.2	2.26	10.46 D
7.1	0.1	0.44	*Zygoribatula longiporosa*	0.7	0.01	0.03 D
			Peloribates paraguensis	6.1	0.08	0.37
			Pilobatella berlesei	0.4	0.004	0.02
			Rostrozetes foveolatus	1.8	0.02	0.08
D50.0	0.21	9.0	*Xylobates indicus*	6.9	0.09	0.43
			Xylobates sp.	11.6	0.34	1.59
D61.0	3.73	16.69	*Hypozetes laysanensis*	45.5	1.61	7.47 D
1.1	0.01	0.05	*Limnozetes* sp.			
3.9	0.06	0.27	*Lamellobates hauseri*	26.4	0.4	1.87
0.7	0.01	0.05	*Paralamellobates schoutedeni*			
D48.9	2.58	11.56	*Galumna flabellifera*	31.0	0.49	2.25 SD
0.7	0.01	0.03	*Galumna* sp. II	13.7	0.21	0.95
			Galumna sp. III	0.7	0.01	0.05
			Xenogalumna sp.	1.8	0.02	0.08
61.0	3.15	14.1	Juveniles & undetermined	64.6	3.95	18.28

D = 'Dominat'; SD = 'Subdominant'; remaining species are 'rare'.

species were rare. Similarly in the polluted site out of 33 species encountered, 7 species were dominant and remaining 26 species were rare. There was no species with a subdominant status in the polluted site. Although there were 27 species common to both the sites, shift in dominance status for many species between the two sites could be observed.

In the unpolluted site, *Scheloribates praeincisus interruptus* was the most frequent (59.2%), most abundant (3.03/sample) and most dominant species (R. A. 14.03%). Whereas in the polluted site, although *Scheloribates albialatus* was the most frequent species (63.1%), *Hypozetes laysanensis* was the most abundant (3.73/sample) and most dominant species (R. A. 16.69%).

All the 8 dominant species encountered, of which 5 were common to both the sites, had a non-random aggregated horizontal pattern of microdistribution (Table 7, Figs. 2 & 3). Although the degree of aggregation varied from species to species it was more in the polluted site than in the unpolluted site for most of the species. In the unpolluted site, the most aggregated species was *Scheloribates albialatus* and the least aggregated specie was *Galumna flabellifera*. On the others hand in the polluted site, maximum degree of aggregation was noted in the case of *Scapheremaeus polysetosus* and the minimum for *Scheloribates fimbriatoides*.

Turning to species richness and species diversity indices as a measure of community complexity and stability it was observed (Table 8) that species richness index of Menhinick was higher in the unpolluted soil (0.63) than in the polluted soil (0.42). Similarly, the Shannon-Weaver's index of species diversity was also higher for the unpolluted site (2.83 ± 0.01) compared to that for the polluted site (2.15 ± 0.01) and the difference between the two was found to be statistically significant at 0.001% level of probablity ($t = 35.9$). Dominance index of McNaughton & Wolf was also found to vary between the

TABLE 7. Fischer's coefficient of dispersion (F), mean Crodding ($\dot{X}$) and mean ($\bar{x}$) domincnt oribatid species in the stuy sites.

Dominant oribatida	Unpolluted site			Polluted site		
	F	$\dot{X}$	$\bar{x}$	F	$\dot{X}$	$\bar{x}$
Scheloribates praeincisus interruptus	11.43	13.46	3.03	12.01	13.66	1.65
S. elegans	7.2	8.46	2.26	5.02	5.62	1.6
S. albialatus	13.19	13.89	1.71	9.89	12.47	3.58
Hypozetes laysanensis	5.5	6.11	1.61	10.08	12.81	3.73
Scapheremaeus polysetosus	12.39	12.99	1.6	13.89	13.82	2.92
Scheloribates fimbriatoides	4.99	5.13	1.14	1.37	0.4	0.03
Galumna flabellifera	1.58	1.07	0.49	11.0	12.59	2.58
Xylobates indicus	1.77	0.87	0.09	6.16	7.17	2.01

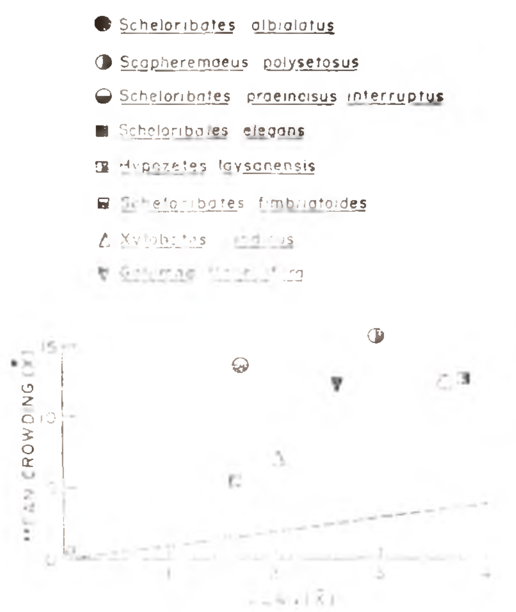

Fig. 2 Mean crowding ($\overset{*}{X}$) plotted against mean (x) of the dominant oribatid species in the polluted site.

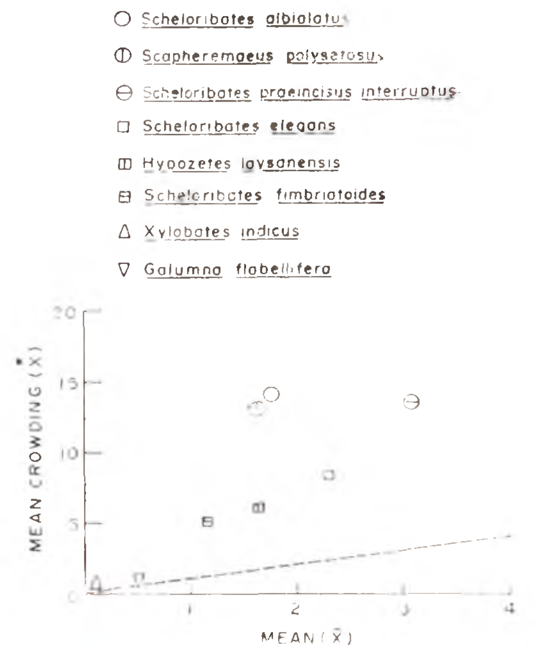

Fig. 3 Mean crowding ($\overset{*}{X}$) plotted against mean (x) of the dominant oribatid ipecies in the unpolluted site.

two sites being higher in the polluted site (32.71) compared to that in the unpolluted site (24.49). Sorensen's quotient of similarity between the two sites, however, was observed to be 65.85% which is suggestive of a 'moderately similar' faunal composition of Oribatida.

TABLE 8. Oribatid density, diversity and Q/S value between the two sites.

Oribatida	Polluted site	Unpollu-ted site
Number/sample	22.33	21.01
Number of species	33	49
Species richness	0.42	0.63
Species diversity (H'±S E)	2.15±0.01	2.83±0.01***
Dominance index	32.71	24.49
% R/S Value	65.85	

*** $P < 0.001$,

DISCUSSION

The results of pilot survey indicates that the two sites under consideration were quite distinct in some major physico-chemical properties of the soil. Most of the edaphic changes in the polluted site, for example, dark colour, increased organic carbon, moisture content, water holding capacity etc. may be associated with the frequent overflowing of the DPL effluents. pH and conductivity of the soil remained unaffected probably due to the 'buffering capacity of soil' (DONAHUE *et al.*, 1977). Among the toxic chemicals, which were present in high amount in the drain water (DE *et al.*, 1980), only ammoniacal nitrogen was found in higher concentration in the polluted soil. Other toxic chemicals

like phenol, sulphide and cyanide could not be detected in the soil perhaps due to soil's unique capacity for detoxification of wastes (MOORE & MOORE, 1976).

The phytosociological analysis of the two sites further supports ecological distinctness between the two sites. Composition of plant community of the polluted site was markedly different from that of the unpolluted site as evident by the decrease in the number of species in the polluted site, particularly disappearence of dicotyledons, and the consequent differences in the importance values of different species. Disappearence of dicots may be attributed to the low level of potassium in the polluted site since availability of potash is low in the alkaline soils. Floral distinctness of the two sites is further corroborated by Sorensen's quotient which suggests that two sites were 'moderately dissimilar' in floral composition. Simplification in composition of plant community in an area affected by effluents from a fertilizer factory has also been observed by SINGH *et al.* (1979).

Turning to the community composition of Oribatida it was found that there was little difference in the average abundance of this group of mite between the two sites. This is in agrement with the findings of MITCHELL *et al.*, (1978) and KRIVOLUTSKY (1979, 1980) who noted that different kinds of pollutants could not alter the population density of soil Acari including Oribatida, but does not tally with the findings of VANEK (1967), DINDAL *et al.* (1975), SINGH *et al.*, (1979) and BHATTACHARYA *et al.* (1980) who found a decrease in the abundance of soil Acari due to various types of pollutants. A marked simplification was, however, noted in the species composition of Oribatida in the polluted site. The reduction in species number was 32.7%. VANEK (1967) found the number of soil oribatida species to be reduced by 42% due to industrial air pollution. DINDAL (1977) also reported that municipal waste water irrigation in soil caused drastic reduction in the number of oribatid species. However, notwithstanding such numerical simplification, the Sorensen's quotient indicates that the two sites under consideration were 'moderately similar' as far as oribatid fauna was concerned. Such apparent similarity between the sites may be due to the close proximity of the two sites. A detailed analysis of other parameters, however, depicts a different picture altogether. There was a clear shift in the dominance status for many species between the polluted and the unpolluted sites. DINDAL (1977) also observed similar change in the dominance status for several oribatid species due to municipal waste water irrigation of soil.

All the eight dominant oribatid species encountered had a non-random, aggregated horizontal pattern of microdistribution. The degree of aggregation was more in the polluted site for most of the species. VANEK (1975) also noted that the aggregation of Oribatida was higher in soil polluted by industrial air pollutants. A more or less similar observation has been made by LUSSENHOP (1973) who found that soil arthropod species were more aggregated near an express way margin receiving high amount of fumes from the vehicles. These findings lead to the assumption that pollution of soil tends to influence the microdistribution pattern of soil Oribatida, making them more aggregated.

Species richness index is known to increase with increased complexity in a community and decreases where simplification occurs within a community. As such in the present study species richness index was found to be much lower in the polluted site suggesting a relative simplification of the oribatid community in that site. Similar reduction in species richness within the oribatid community has also been noted by DINDAL (1977) due to municipal waste water irrigation of soil. Like species richness, species diversity can also be correlated with the complexity and stability of the ecosystem. This index tends to be higher in more complex and stable habitats and lower in simple and less complex ones. In the present investigation species diversity index was significantly lower ($P < 0.001$) in polluted site in comparison to that in the unpolluted site suggesting relative harshness of the polluted site sustaining less complex community. Suppression of species diversity of Oribatida due to municipal waste water irrigation of soil have been reported by DINDAL *et al.* (1975) and DINDAL (1977).

This aspect can be further elaborated with the anlysis of dominance index of McNaughton & Wolf. According to KARR (1971) dominance index of Avifauna increases with the increasing harshness of the environment and decreases with the vegetational growth. Similar correlation between the harshness of the environment vegetational growth and dominance index of oribatid fauna of soil has been suggested by BHATTACHARYA *et al.* (1981). In the present study, dominance index of Oribatida was found to be more in the polluted site which confirms the above contention and is suggestive of the increased harshness of the polluted site, which besides regularly receiving effluents had limited fioral components compared to unpolluted one.

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THE ROLE OF FLIGHT SURFACE IN TETHERED FLIGHT OF INSECTS

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This paper is confined to determine the degree of influence of flight surface on wingbeat frequency and induced velocity of air, when the flier is under tethered state of flight. The wing parameters are altered by performing mutilation along the transverse and longitudinal directions of the flight surface separately. These experiments yield results that are in good agreement with the theoretical values computed by Mass-flow and Helicopter theories for wingbeat frequency and induced velocity respectively.

(*Key words:* flight surface, tethered flight, insect wingbeat frequency, induced velocity of air)

INTRODUCTION

Several attempts have been made in the past (SOTAVALTA, 1954, 1952; PURANICK *et al.*, 1976; ADEEL AHMAD, 1978, 1982) to study the influence of wing mutilation on wingbeat frequency by performing wing mutilation along the transverse direction of the wing. The studies, however, do not throw enough light as to what extent the wingbeat frequency gets influenced due to wing mutilation along the transverse direction of the wing. Besides this, there exists no information regarding the contribution of the longitudinal wing mutilation to the variation of wingbeat frequency.

Recently it has been proposed (PURANIK *et al.*, 1977) that the wing beat frequency of any flier in the hovering state of flight could be determined from a knowledge of the rate of mass flow of air induced downward by the wing disc. This obviously shows that the wingbeat frequency is a function of the body mass, wing span and wing breadth. Hence any variation in these parameters produced by the wing mutilation should introduce corresponding variations in the wingbeat rate of the flier. On the other hand the mechanical oscillator theory reported by GREENEWALT (1960) assumes that wingbeat frequency is a function of wing length alone. As a consequence of this, wingbeat frequency should be independent of longitudinal wing mutilation.

Apart from the wingbeat frequency the induced velocity of air is also a function of the body parameters, namely the body mass and wing span of the flier as reported by PENNYCUICK (1968). According to this theory the induced velocity of air should increase under transverse wing mutilation and should be independent of longitudinal wing mutilation.

In view of this it is thought worthwhile to determine the wingbeat frequency under different degrees of wing mutilation along the transverse and longitudinal directions in order to examine the validity of these theories in influencing the wingbeat frequency and induced velocity of air in a quantitative manner

THEORETICAL CONSIDERATIONS

According to mechanical oscillator theory developed by GREENEWALT (1960) a flier is considered as a driven damped oscillator due to the constancy of wing-beat rate under different states of flight. With a number of assumptions the solution of the differential equation for undamped oscillator is given by

$$\nu l^{n} = \text{Constant} \qquad \ldots\ldots\ldots 1$$

Therefore $\nu = f(l)$

where ν is the wingbeat rate and l is the wing length expressed in millimeters. n lies between 1—1.25.

On the other hand mass-flow theory characterises flight to be associated with a frequency spectrum and ascribes different values of wingbeat rates for different states of flight and defines the frequency of the wingbeat in the hovering state of flight as the hovering frequency, ν_h. The reacting force, that balances the gravitational force is computed by considering the rate of mass flow of air induced downwards due to wingbeat through the wing disc for hovering flight, due to which the wing-beat frequency,

$$\nu_h = \frac{K\, M_f}{L^2\, B_{eff}} \qquad \ldots\ldots\ldots 2$$

where $K = \frac{8g}{\pi\rho}$; M_f = Body mass;

L = Wing span; B_{eff} = Effective wing breadth.

Hence $\nu_h = f(M_f, L, B_{eff})$

But according to helicopter theory the velocity of air induced downward direction (v_{iz}) is proportional to the square root of disc loading for hovering state of flight. The expression for v_{iz} may be written as

$$v_{iz} = \sqrt{\frac{W}{S_d} \cdot \frac{1}{2\rho}} \qquad \ldots\ldots\ldots 3$$

Thus $v_{iz} = f(M_f, L)$

From equations 2 and 3 a simple relation between wingbeat frequency (ν_h) and induced velocity of air (v_{iz}) can be deduced (GOPALA KRISHNA *et al.*, 1977) which may be written as

$$v_{iz} = \sqrt{g/4\,\nu_h\, B_{eff}} \qquad \ldots\ldots\ldots 4$$

Thus it is obvious that

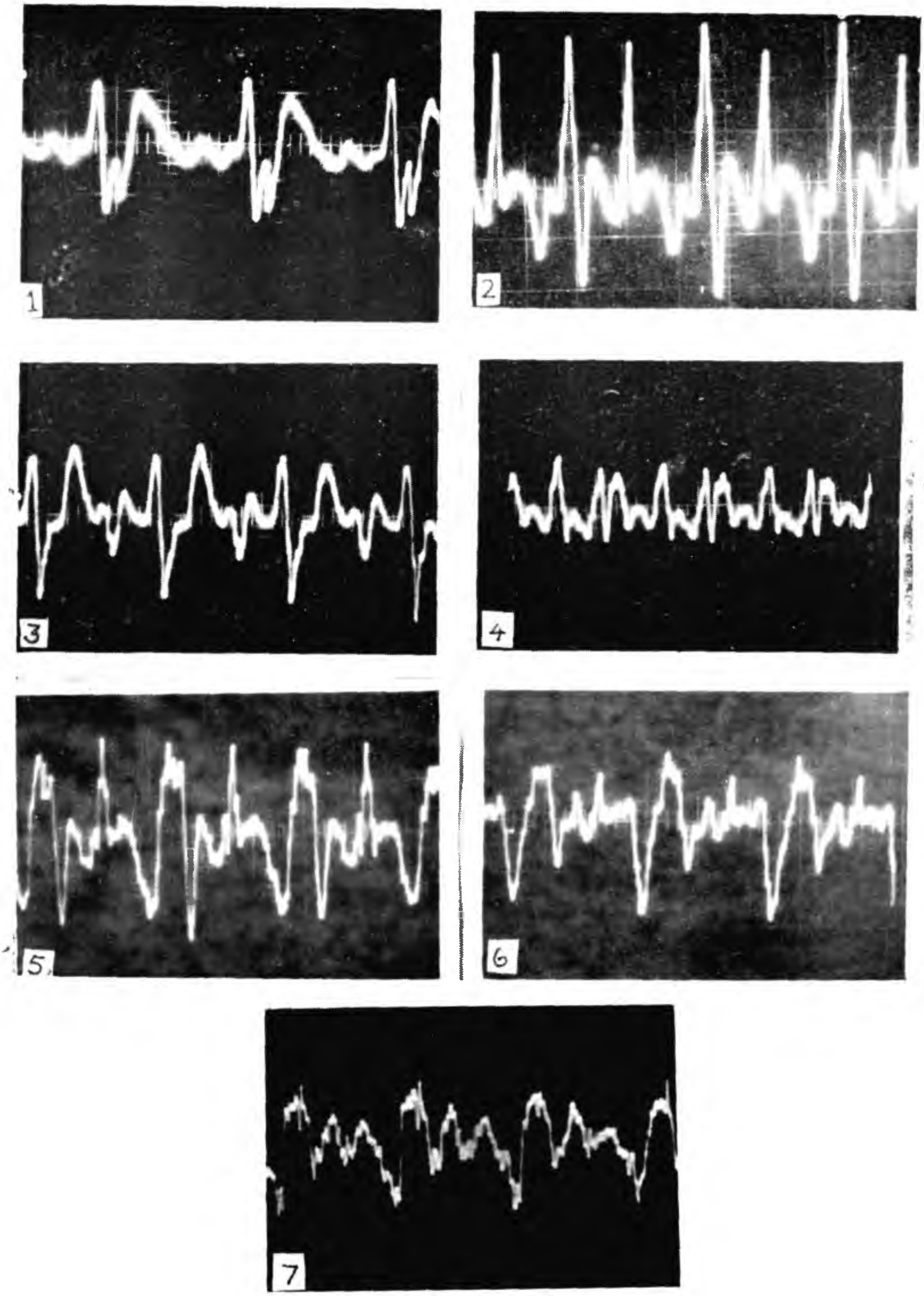
$v_{iz} = f(\nu_h, B_{eff})$ at a given place.

EXPERIMENTAL

The flight sound technique has been used to determine the wingbeat frequency of 15 samples of *Tesseratoma javanica* under tethered state of flight before and after wing mutilation. The first 10 samples have been chosen for determining the variation in the wingbeat frequency due to wing mutilation along the transverse direction, while the remaining samples are subjected to the mutilation along longitudinal direction. In both the cases the wing mutilation has been confined to the forewing of the insect as the earlier studies (PURANIK & ADEEL AHMAD, 1976) indicated the lack of independent movement for hindwing. Figs. 1—7 are the typical flight sound patterns showing the progressive variation in the wingbeat frequency with the degree of wing mutilation along transverse and longitudinal directions respectively. The wingbeat frequency and induced velocity of air have been determined by using equations (1,2) and (3) respectively under normal and mutilated conditions after measuring the body parameters—mass, wing span and effective wing breadth of the insect at every stage.

RESULTS AND DISCUSSION

Table 1 gives data of wingbeat frequency using equation 1 and 2 and induced velocity by equation 3 along with the experimental values under normal and different stages of wing mutilation for two insects only. It can be seen from Table 1 that the degree of mutilation is confined upto 48 per cent in transverse and 23 per cent in longitudinal directions. It is interesting to note



Figs. 1—7. Typical flight sound patterns showing the progressive variation in the frequency of wing beat with degree of mutilation. Time mark—1 div. = 5ms; 1—4 under transverse direction; 1. $\nu_0 = 70$; 2. $\nu_0 = 80$; 3. $\nu_0 = 85$; 4. $\nu_0 = 105$; 5—7. under longitudinal direction: 5. $\nu_0 = 75$; 6. $\nu_0 = 85$; 7. $\nu_0 = 90$.

TABLE 1 Transverse mutilation of fore wing.

Degree of mutilation %	M_t (gm)	Frequency of wing beat (Hz)				Induced velocity cm/sec		Rate of mass flow $\frac{dm}{dt}$ gm/sec	
		ν_c	ν_g	ν_h	ν_o	(v_{iz}) Eqn. 3	(v_{iz}) Eqn. 4	$(\gamma S_d B\, f f \rho \nu_h)$	$(S_d v_{iz} \rho)$
0.0	0.781	92	101	51	60	119	125	3.33	3.22
12.3	0.776	118	120	62	70	133	134	3.10	2.87
20.8	0.770	130	146	74	80	150	149	2.94	2.51
31.7	0.759	150	208	94	92	182	167	2.63	2.04
Longitudinal mutilation									
0.0	1.017	126	96	65	73	126	126	4.12	4.01
12.7	1.012	144	96	72	80	126	126	3.96	3.92
20.6	1.005	158	96	80	85	126	126	3.92	3.92

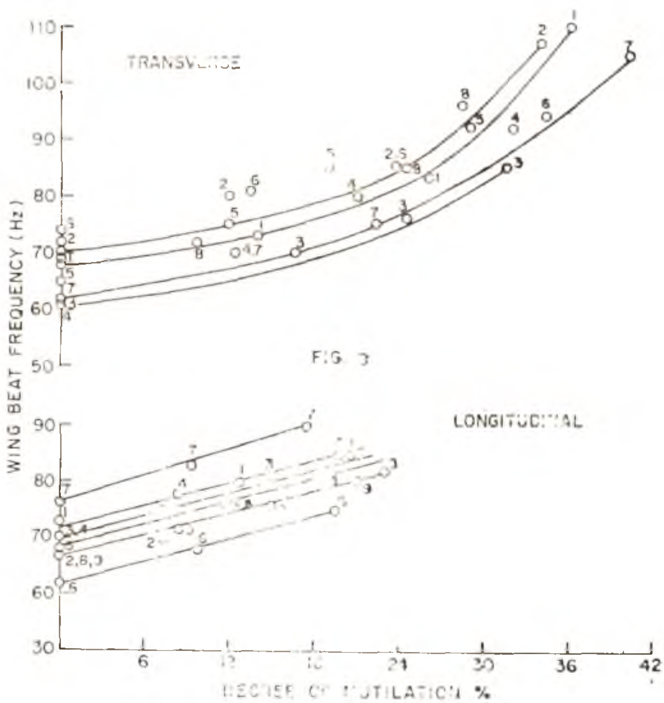
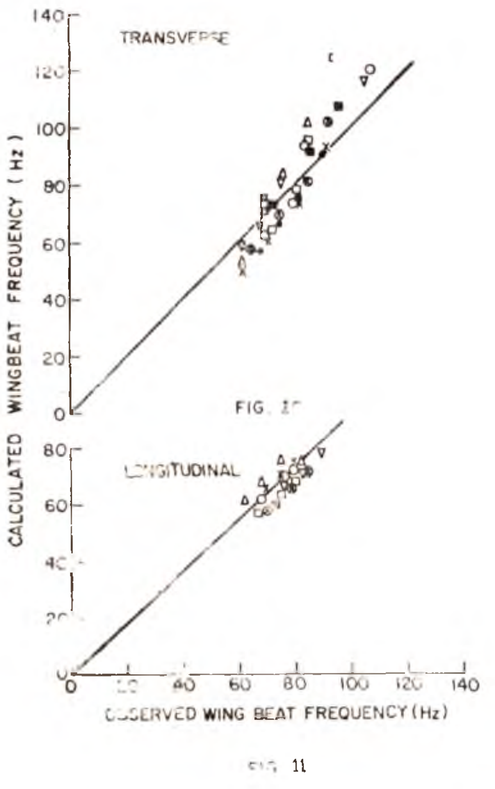


FIG 9

Figs. 8—9. Showing the variation of frequency of wing beat with degree of mutilation; Fig. 8. under transverse direction; Fig. 9. under longitudinal direction.

that the experimental values are in agreement with those calculated by Mass-flow theory (eqn. 2) and Helicopter theory (eqn. 3) for wingbeat frequency and induced velocity respectively. However, the mechanical oscillator theory gives values for wingbeat frequency which are found to be completely different from the experimental values. The same is noticed with CRAWFORDS' relation (CRAWFORD, 1971).

Figs. 8 and 9 give the plots between the degree of mutilation and wingbeat frequency in transverse and longitudinal directions. In both the cases the wingbeat frequency is found to increase with the degree of mutilation in a similar manner upto about 24 per cent of mutilation. Beyond this a non-linearity has been noticed in the case of transverse mutilation.



Figs. 10—11. Showing the agreement between the calculated and observed frequency of wing beat; 10. under transverse mutilation; 11. under longitudinal mutilation.

Figs. 10 and 11 are the plots between the calculated (Mass-flow theory) and observed wingbeat frequencies under different degrees of transverse and longitudinal mutilations, to show the agreement between them.

Figs. 12 and 13 give the plots between the degree of mutilation and induced velocity of air. It is interesting to note that in the case of transverse, the induced velocity is found to increase with the degree of mutilation, while it is constant in the case of longitudinal which is in accordance with the principles of helicopter theory.

Fig. 14 gives the plot between the rate of mass-flow of air (GOPALA KRISHNA *et al.*, 1980) and mass of the flier for the samples shown in the Table 1. The broken line is the 'hovering flight line', whereas the solid one is the experimental best fit line. It is further interesting to note that the rate of mass flow of air induced downwards decreases as the degree of wing mutilation is increased irrespective of whether the mutilation is longitudinal or transverse and it falls below the hovering flight line which can be seen from Fig. 14. As the rate of mass flow of air approaches zero, which is achieved by completely mutilating the wing, the corresponding x-coordinate gives the mass of the flier without the flight surface. The experimental values are in agreement with those obtained from the Fig. 14.

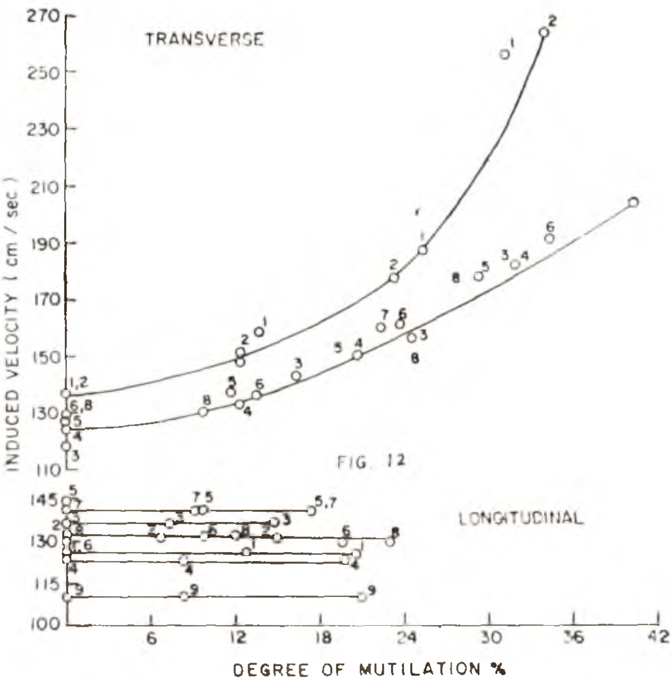


FIG 13

Figs. 12—13. Showing the variation in the induced velocity of air during wing mutilation; Fig. 12. transverse; Fig. 13. longitudinal.

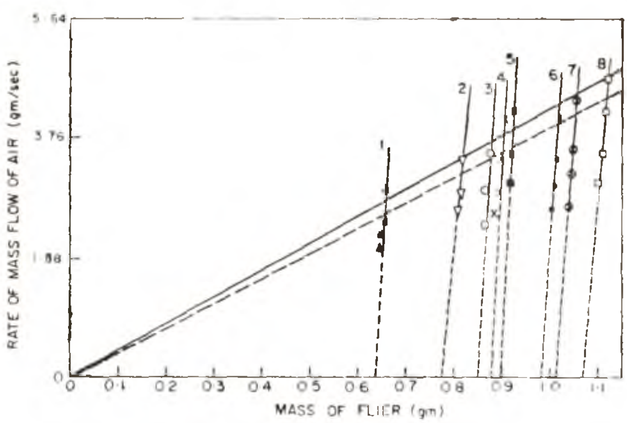


FIG 14

Fig. 14. Gives the plot between the rate of mass flow of air verses the mass of the flier.

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EFFECT OF SPLIT DOSES OF GRANULAR INSECTICIDA APPLICATION ON SHOOTFLY, *ATHERIGONA NAQVII* (STEYSKAL) INCIDENCE ON WHEAT CROP

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To avoid shootfly (*Atherigona naqvii*) incidence in early and late sown wheat crop, a dose of 2.5 kg a i/ha of each phorate 10G and aldicarb 10G evaluated in split doses under field trials during *rabi* 1977 and 1978 respectively. Among three methods of granulur application, the maximum protection of the crop was found in the plots treated with phorate applied in seed furrow (1.5 kg a i ha) at the time of sowing followed by top dressing (1.0 kg a i/ha) at the time of first irrigation. Moreover, the basal dose (2.5 kg a i/ha) of phorate granule applied in seed furrow was found more effective in early sown crop than late, while split dose (1 5 and 1.0 kg a i ha) of the same applied on first and second irrigations respectively gave better protection to the late sown crop than early sown.

(Key words: shootfly, *Atherigona naqvii*, granular insecticides)

INTRODUCTION

The shootfly, *Atherigona naqvii* (Steyskal) is known to occur in several countries of the world (PONT, 1972). Like other species of *Atherigona* damaging some of the important cereal crops, shootfly, *A. naqvii* (S.) has also been reported to cause considerable losses to the crops of wheat (KUNDU & PREM KISHORE, 1971; KHAN & SHARMA, 1974; SINGH *et al.*, 1374), barley (SRIVASTAVA *et al.*, 1969); and maize (SANDHU & KAUSHAL, 1976) in different parts of our country Early and late sown crops suffered more from shootfly attack (SINGH *et al.*, 1974). Though several granular insecticides have been tested against wheat stemfly, *A. bituberculata* Malloch in different application methods (RAWAT & SAHU, 1970; SINGH *et al.*, 1969) none of the workers has tried to test the granules in split doses against this shootfly. Therefore, the present studies were undertaken to find out the proper dose, time and method of granular application to combat the fly activity occurring in early and late sown wheat crops.

MATERIALS AND METHODS

Early and late sown field trials were laid out during *rabi* 1977 and 1978 respectively a Agricultural Research Station Durgapura, Jaipur. There were seven treatments including check. Treatment was replicated four times. The net plot size was 3×1.5 m with six experimental rows. The varieties used for early and late sown crop were Kalyan Sona and Sonalika respectively. Kalyan Sona was seeded @ 100 kg/ha on 19.10.77 and Sonalika @ 125 kg/ha on 5.1.78. The dose, time and method of application of both phorate and aldicarb were same as below (details shown in Table 1).

(i) 2.5 kg a i/ha basal (seed furrow); (ii) 1.5 kg a i/ha basal (seed furrow) + 1.0kg a i/ha topdressing (first irrigation); (iii) 1.5

kg a i/ha top dressing (first irrigation)+ 1.0 kg a i/ha broad casting (second irrigation).

The fertilizer NPK was given @ 80:40:20 a day before sowing. Irrigations necessary for applications of granule were given 13/11, 23/11 and 18/12/77 in early sown crop and on 7/2, 20/2, and 4/3/78 in late sow. The granules were applied 2–3 days after irrigation followed by an immediate hoeing. Dead hearts recorded 15, 30, 45 and 60 days after germination from three randomly selected ear-marked units of one metre raw length in each plot. The average of plant stand per metre was also calculated from the same three units. The damaged shoots were pulled out at the time of each observation to avoid their inclusion insubsequent counts.

RESULTS AND DISCUSSION

The data presented in Table I reveal that there was no significant adverse effect of both granular insecticides on germination. In early sown crop. statistically low infestation was registered in all the treated plots than untreated. During the crop season, the lowest infestation was observed in the plots treated with phorate T_2 followed by phorate T_1. However, at 45 days after germination, there was no significant difference among phorate T_1, T_2 and aldicarb T_5. The basal dose of aldicarb granule T_4 was found more effective only at 15 days after germination as there was no significant difference between phorate T_2 and aldicarb T_4. Similarly in late sown crop significantly reduced number of infested tillers were obtained in all the treated plots than untreated. However, at 15 days after germination, the crop did not show any infestation. At 45 and 60 days after germination, the lowest infestation was again recorded in phorate T_2 followed by phorate T_3, although there was no significant difference between these two treatments on any of the two observation dates. The basal dose of phorate granule T_1 gave poor protection to the crop beyond 30 days after germination in comparison to the split dose of phorate T_3, applied on first and second irrigation.

A conspectus of all these observations with respect to superiority of insecticide, dose and method of application, the phorate was found comparatively more effective than aldicarb Also, no adverse effect of phorate granule on germination and its effectivenees against shootfly. *A. naqvii* (S.) control observed in the present studies agree with the findings of RATHORE *et al*, (1976). From the table it is evident that during the peaks of infestation, observed 30 and 60 days after germination in early and late sown crop the lowest percentages i.e. 8.96 and 7.69 of infested shoots (dead heart) were recorded in split dose treatment of phorate T_2 as compared to 20.68 and 13.12 per cent in control in early and late sown crops respectively.

WALKER (1971) also found good results with split dose application and he observed that phorate granule @ 1 68 kg a i ha in the seed furrow was most effective against Hessian fly, *Mayetiola destructor*, Say Dipt. Cecidomyiidae on *durum* wheat, with 69-92 per cent control of tillers infested, and the granules broadcasted over young barley crop at the same rate gave 74 per cent control. Results with regard to more effectiveness of basal dose (2.5 kg a i ha) of phorate granule in early than late sown crop showed the close resemblence with those of SINGH *et al.* (1969) who has reported that three weeks after sowing, phorate granule applied @ 25 kg/ha with seed provided significant control of wheat stemfly, *A. bitubeiculate*, Malloch in reducing the level of infestation to 5.65 per cent in treated plots

TABLE 1. Effect of granules on germination and shootfly infestation in wheat crop.

Insecticide kg a i/ha	Time and method of granule application	Early sown (1977) Plant stand per metre row length 24.10.77	Early sown (1977) Per cent dead hearts recorded (days after germination) 15 8/11	30 23/11	45 8/12	60 23/12	Late sown (1978) Plant stand per metre row length 14.1.78	Late sown (1978) Per cent dead hearts recorded (days after germination) 15 28/1	30 12/2	45 27/2	60 15/3
T_1 Phorate 10G 2.5	Basal (Seed furrow)	51.37	3.00 (9.95)	10.00 (18.40)	7.37 (15.70)	0.20 (1.65)	47.70	—	0.00 (0.00)	3.00 (9.92)	10.27 (18.69)
T_2 Phorate 10G 1.5 + 1.0	Basal (Seed furrow) Top dressing (First irrigation)	52.79	3.00 (10.34)	8.96 (16.62)	7.00 (15.30)	0.00 (0.00)	47.07	—	0.00 (0.00)	2.60 (9.23)	7.69 (16.08)
T_3 Phorate 10G 1.5 + 1.0	Top dressing (First irrigation) Broad casting (Second irrigation)	60.12	8.34 (16.72)	14.54 (22.19)	9.72 (19.54)	0.30 (2.16)	50.09	—	1.58 (7.10)	2.85 (9.71)	8.00 (16.43)
T_4 Aldicarb 10G 2.5	Basal (Seed furrow)	52.39	4.17 (11.75)	12.91 (20.39)	9.40 (17.85)	0.41 (2.56)	52.15	—	0.72 (3.90)	4.62 (12.38)	11.95 (20.19)
T_5 Aldicarb 10G 1.5 + 1.0	Basal (Seed furrow) Top dressing (First irrigation)	56.99	5.02 (13.27)	11.17 (19.02)	8.11 (16.49)	0.25 (1.55)	49.00	—	0.24 (1.92)	3.55 (10.93)	9.62 (18.07)
T_6 Aldicarb 1.0G 1.5 + 1.0	Top dressing (First irrigation) Broad casting (Second irrigation)	59.07	11.50 (19.79)	16.98 (23.72)	10.55 (18.94)	0.00 (0.00)	51.99	—	2.00 (8.12)	4.00 (11.53)	9.28 (17.70)
T_7 Control		58.58	9.10 (17.41)	20.68 (28.06)	14.78 (21.52)	0.54 (3.55)	52.15	—	4.46 (12.15)	6.80 (15.07)	13.12 (21.19)
CD (P = 0.05)		NS	1.49	1.42	1.64	NS	NS	NS	2.20	0.49	1.00

Figures in parentheses are angular transformations.

as compared to 42.14 per cent in control while at 7 weeks no significant difference including control was obtained. Perhaps the difference in late sown crop may be attributed to the delayed peak period of incidence as it was observed to be 60 days as compared to 30 days after germination in early sown wheat crop.

From the above discussion it is clear that both the granules have no adverse effect on germination and were effective in controlling of the pest. However, phorate granule was found more effective than aldicarb. The application of total dose (2.5 kg ai/ha) of phorate granule in two splits ie 1.5 kg ai/ha in seed furrow and 1.0 kg ai/ha at the time of first irrigation offered the maximum protection to the crop. Moreover, the total dose (2.5 kg ai/ha) of phorate granule applied in the seed furrow gave comparatively better control in early than late sown crop while the split doses of phorate granule applied on first (1.5 kg ai/ha) and second (1.0 kg ai/ha) irrigation proved more effective in late than early sown crop.

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EFFICACY OF SOIL DRENCHING ON THE CONTROL OF SWEET POTATO WEEVIL, *CYLAS FORMICARIUS* FABRICIUS[1]

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Field trials were conducted for two seasons to study the efficacy of eight insecticides each at 0.05% concentration, applied as basal drenches for the control of sweet potato weevil, *Cylas formicarius* Fab. Each insecticide was applied at three frequencies viz. once (70 days after planting), twice (50 and 70 days after planting) and thrice (30, 50 and 70 days after planting). Results showed that drenching twice or thrice with fenthion, endosulfan or fenitrothion was highly effective to reduce weevil infestation leading to economic return.

(Key words: insecticidal drenching, *Cylas formicarius,* sweet potato weevil, infestation)

Sweet potato, *Ipomoea batatus* is attacked usually by the weevil *Cylas formicarius* Fab. (Curculionidae: Coleoptera) causing severe damage to the crop in the field and to the tubers in storage. The damage ranging from 40 to 88% has been reported by JAYARAMAIAH (1975), SUBRAMANIAM *et al.* (1977), PILLAI *et al.* (1981) and RAJAMMA (1982). As the developmental stages of the weevil are inside the plant parts, its control is often difficult. The efficacy of spraying the crop with insecticides like DDT, carbophenothion, fenthion, carbaryl, fenitrothion, monocrotophos, chlorodimeform, and quinalphos has been reported by SUBRAMANIAM *et al.* (1973), JAYARAMAIAH (1975) and PILLAI *et al.* (1981).

With a view to assesing the efficacy of soil drenching on the control of sweet potato weevil a field experiment was conducted using different insecticides at different frequencies of application and the results obtained are embodied in this communication.

MATERIALS AND METHODS

Field experiments were conducted for two seasons at Central Tuber Crops Research Institute in randomised block design with eight insecticides (Table 1). The variety Kanjahangad local was used in these experiments. Ridge method of planting was adopted with a plot size of 3 × 2.4 sq m adopting a spacing of 60 × 20 cm. Recommended manurial practices have been followed. Weevil free planting materials from a primary nursery already kept protected with fenthion spray were used for planting. The insecticide emulsions were applied as soil drenches at the base of the plants using a water can at the rate of 40 lit. of insecticide solution per 100 sq m area. Each insecticide was applied at three frequencies viz., (1) three applications on 30, 50 and 70 days after planting; (2) two applications on 50 and 70 days after planting; and (3) single application on the 70th day after planting. The crop was harvested at 110 days maturity. Results were assessed on the basis of the percentage of tuber damage, marketable tuber yield and cost benefit ratio obtained. Cost of benefit ratio was calculated by the formula– Return

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TABLE 1. Mean percentage of damage and average yield of quality tubers and cost benefit ratio under different insecticide treatments.

Insecticide concentration and frequency of application	Mean percentage of tuber damaged			Average yield of good tubers (tons/ha)	Cost benefit ratio*
	November–February 1980-81	June–September 1981	Mean		
Fenthion 0.05%					
Once	30.2 (33.3)	25.3 (30.2)	27.8	9.0	1:4.17
Twice	13.8 (21.8)	8.4 (16.8)	11.1	13.8	1:5.72
Thrice	6.4 (14.7)	0.7 (4.8)	3.6	16.0	1:4.76
Monocrotophos 0.05%					
Once	40.2 (39.3)	34.6 (36.0)	37.4	7.8	1:0.12
Twice	16.5 (24.0)	12.3 (20.5)	14.4	12.2	1:1.00
Thrice	8.2 (16.6)	6.0 (14.2)	7.1	14.5	1:0.84
Quinalphos 0.05%					
Once	32.3 (34.6)	26.2 (30.8)	29.3	8.0	1:0.22
Twice	13.3 (20.4)	8.6 (17.1)	11.0	13.7	1:1.44
Thrice	6.3 (14.5)	2.9 (9.8)	4.6	15.9	1:1.10
Endosulfan 0.05%					
Once	28.3 (32.1)	24.7 (29.8)	26.5	9.6	1:3.83
Twice	12.2 (20.4)	6.7 (15.0)	9.5	13.7	1:4.29
Thrice	5.2 (13.2)	1.4 (6.8)	3.3	16.3	1:3.70
Fenitrothion 0.05%					
Once	38.7 (38.6)	30.8 (33.7)	34.8	8.8	1:2.60
Twice	15.7 (23.3)	9.8 (18.2)	12.8	13.0	1:3.60
Thrice	8.1 (16.5)	2.9 (9.7)	5.5	15.2	1:3.09
Aldrin 0.05%					
Once	17.2 (24.5)	7.4 (5.8)	12.3	12.8	1:6.49
Twice	8.8 (17.3)	2.9 (9.8)	5.9	15.0	1:3.97
Thrice	5.4 (13.4)	1.9 (5.4)	3.7	15.4	1:2.47
Malathion 0.05%					
Once	39.2 (38.8)	32.2 (34.6)	35.7	8.0	1:1.16
Twice	23.4 (28.9)	17.2 (24.5)	20.3	9.9	1:1.15
Thrice	12.3 (20.5)	6.8 (15.1)	9.6	14.0	1:1.99
Methyl parathion 0.05%					
Once	40.6 (39.6)	33.0 (35.1)	36.8	7.4	1:0.69
Twice	24.6 (29.7)	18.4 (25.4)	21.5	9.6	1:1.27
Thrice	13.2 (21.3)	7.9 (16.3)	10.6	13.6	1:2.24
Tontrol	50.6 (45.3)	38.2 (38.2)	44.4	6.1	
SD (0.05)	6.73	5.40		2.1	

Figures in parenthesis are transformed values.

* Cost of cultivation that are common for control and treatments are not taken into account; only the additional expenditures involved for treatments are eonsidered here.

over control cost of insecticides and labour charges for application.

RESULTS AND DISCUSSION

Results of the experiments conducted for two seasons (Table 1) revealed that at single application of aldrin, 70 days after planting was most effective followed by endosulfan and fenthion. At two applications, the insecticides like aldrin, endosulfan, quinalphos, fenthion, fenitrothion and monocrotophos were effective as the mean percentage of tuber damage in these treatments ranged from 5.9 to 14.4 against 44.4% in the control. Malathion and methyl parathion were not so effective at two applications. In three rounds of drenching all the insecticides were effective. Aldrin was found to be effective at 1, 2 and 3 applications; endosulfan, fenthion, quinalphos, and monocrotophos at 2 and 3 drenchings and malathion and methyl parathion at 3 drenchings.

All the insecticidal treatments except single drenching of malathion and methyl parathion gave significant increase in marketable tuber yield compared to the control. Maximum tuber yield of 16.3 tons/ha was recorded in endosulfan (three drenchings) treatment closely followed by fenthion (16.0 tons), quinalphos (15.9 tons) aldrin (15.4 tons) and fenitrothion (15.2 tons) all at three drenchings and were significatly superior to other treatments. In control the yield was only 6.1 tons.

The cost benefit ratio for different insecticides (Table 1) indicated that the ratio was highest in the case of aldrin (single application) followed by fenthion, endosulfan and fenitrothion.

Though quinalphos and monocrotophos were highly effective in controlling the weevil infestation, they were not economical as the cost of the chemicals was high.

Based on weevil control, yield of marketable tubers and cost benefit ratio it is concluded that two drenchings of fenthion, endosulfan and fenitrothion and single application of aldrin are more effective and economical. JOHNSON *et al.* (1979) reported the efficacy of malathion, methyl parathion and fenthion at two drenchings at monthly intervals. But in the present investigation only fenthion was found effective and malathion and methyl parathion were less effective.

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EFFECTIVENESS OF SYNTHETIC PYRETHROIDS AGAINST THE PEST COMPLEX OF BRINJAL

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Effectiveness of synthetic pyerthroids in comparison to commonly recommended insecticides was worked out against shoot and fruit borer, ash weevil adults, aphid and jassid infesting brinjal. All the synthetic pyrethroids were highly effective against shoot and fruit borer and ash weevil but showed less toxicity against aphid and jassid. Endosulfan and carbaryl were moderately effective against shoot and fruit borer and ash weevil but proved superior over synthetic pyrethroids in controlling aphid and jassid.

(*Key wrds:* Synthetic pyrethroids, brinjal, pest complex)

INTRODUCTION

Synthetic pyrethroids are broad spectrum insecticides developed in late 1970s which control a variety of arthropod pests (ELLIOTT, 1977). The effectiveness of synthetic pyrethroids has been worked out against brinjal fruit and shoot borer (KUPPUSAMY & BALASUBRAMANIAN, 1980; NIMBALKAR & AJRI, 1981; ABDUL ALLAM *et al.*, 1982; AZEEZ BASHA *et al.*, 1982) but information is lacking for other pests infesting brinjal. As the suitability of chemicals for integrated pest management requires complete assessment of effects on the entire species complex of crop, under present studies efforts have been made to test the efficacy of synthetic pyrethroids in relation to conventional insecticides against major pests of brinjal viz., fruit and shoot borer *Leucinodes orbonalis* Guen; ash weevil adults, *Myllocerus subfasciatus* Guerin; aphid, *Aphis gossypii* Glov. and jassid, *Amrasca biguttula biguttula* Ishida.

MATERIALS AND METHODS

A field experiment was conducted in Randomised Block Design with brinjal vareity "*Pusa purple cluster*" during November—December, 1982. There were nine insecticidal treatments (Tabe 1) and a check, all replicated thrice in individual plots of 5m × 3m. First spraying was done 50 days after transplanting and at this stage pre- and post treatment counts of ash weevil adults (on whole plant) and nymphs of aphid and jassid (on 3 leaves each of 10 plants per replication) were made. For shoot and fruit borer, five sprayings were given at fortnightly intervals commencing from 70 days after transplanting and data on percentage infestation both on fruit number as well as weight basis were recorded at each pickings and pooled for analysis.

RESULTS

Results on the effectiveness of different treatments against fruit borer, ash weevil adults, aphid and jassid are presented in Tables 1 to 4. All the treatments were superior over control in reducing the fruit borer incidence (Table 1). Fenvalerate (75 g ai/ha) was best resulting least borer infestation closely followed by decamethrin and cypermethrin. Permethrin (75 g ai/ha) was significantly inferior than fenvalerate and decamethrin in reducing the borer incidence but showed significantly less infestation when compared with endosulfan and carbaryl. All

TABLE 1. Effectiveness of different treatment against *Leucinodes orbonalis* Guen.

Treatments	Dose a i/ha (ga)	Mean % infestation* No. basis	Wt. basis
Decamethrin	10	(0.40) 5.43^{ab}	(0.45) 5.57^{a}
Cypermethrin	30	(0.55) 5.81^{abc}	(0.57) 5.85^{a}
Fenvalerate	75	(0.30) 5.11^{a}	(0.33) 5.21^{a}
Fenvalerate	50	(1.31) 7.71^{bc}	(1.29) 7.67^{ab}
Permethrin	75	(1.50) 8.09^{c}	(1.75) 8.58^{b}
Permethrin	50	(3.94) 12.06^{d}	(4.01) 12.16^{c}
Carbaryl	1500	(6.15) 14.81^{e}	(6.22) 14.89^{d}
Endosulfan	400	(5.0[illegible]) 13.56^{de}	(4.99) 13.45^{cd}
Quinalphos	400	(13.73) 22.13^{f}	(13.85) 22.23^{e}
Control	—	(35.97) 37.13^{g}	(36.28) 37.32^{f}
SEM		0.84	0.85
CD at 5%		2.50	2.54

* Sin^{-1} 0.5 $\sqrt{X}$ values Figures. in parantheses are original values. Treatment means followed by the same alphabet are not significantly different.

TABLE 2. Effectiveness of different treatments against the adults of *Myllocerus subfasciatus* Guerin.

Treatment	Dose ai /ha (g)	Pre-treatment count*	% reduction in population after** 24 hrs	5 days	10 days
Decamethrin	10	(64.00) 1.81	(98.19) 83.09^{a}	(99.16) 84.55^{a}	(96.39) 80.09^{ab}
Cypermethrin	30	(61.00) 1.78	(95.48) 78.96^{a}	(97.26) 81.36^{a}	(95.41) 78.50^{ab}
Fenvalerate	75	(65.00) 1.80	(98.36) 83.34^{a}	(99.22) 84.69^{a}	(96.29) 80.37^{a}
Fenvalerate	50	(62.00) 1.81	(97.81) 72.82^{a}	(97.18) 81.26^{ab}	(89.77) 71.81^{abc}
Permethrin	75	(68.33) 1.82	(98.40) 83.35^{a}	(97.45) 82.57^{a}	(96.63) 80.78^{a}
Permethrin	50	(61.33) 1.80	(96.25) 80.59^{a}	(95.89) 79.65^{ab}	(81.23) 64.86^{c}
Carbaryl	1500	(60.67) 1.78	(78.98) 64.73^{b}	(91.08) 73.50^{b}	(57.58) 49.81^{d}
Endosulfan	400	(65.00) 1.83	(91.13) 7[illegible]^{ab}	(96.01) 79.88^{ab}	(85.25) 67.97^{bc}
Quinalphos	400	(58.67) 1.76	(30.00) 33.59^{c}	(45.17) 42.46^{c}	(36.91) 37.53^{d}
Control	—	(58.33) 1.77	+(8.82) 11.27	+(5.79) 8.34	+(8.67) 9.98
SEM			3.57	2.61	4.17
CD at 5%		NS	10.70	7.83	12.49

* Log X + 2 values ** Sin^{-1} 0.5 $\sqrt{X}$ values. + Percentage increase. Figures in parentheses are original values. Treatment means followed by the same alphabet are not significantty different.

TABLE 3. Effectiveness of different treatments against *Aphis gossypii* Glove.

Treatments	Dose ai/ha (g)	Pre-treatment count*	% reduction in population after treatment**		
			24 hrs	5 days	10 days
Decamethrin	10	(343.67) 2.53	(57.42) 49.56^{cd}	(65.88) 54.54^{de}	(60.52) 51.41^{b}
Cypermethrin	30	(321.67) 2.45	(65.95) 54.73^{c}	(75.73) 60.94^{cd}	(58.71) 50.29^{b}
Fenvalerate	75	(273.33) 2.44	(56.93) 49.26^{cd}	(53.63) 47.40^{ef}	(51.62) 46.20^{b}
Fenvalerate	50	(252.67) 2.52	(47.57) 43.87^{d}	(52.33) 46.60^{ef}	(48.60) 45.65^{b}
Permethrin	75	(363.33) 2.56	(51.46) 46.10^{d}	(49.93) 45.27^{ef}	(48.71) 44.52^{b}
Permethrin	50	(314.67) 2.48	(46.02) 42.93^{d}	(38.42) 38.46^{f}	(36.49) 37.40^{c}
Carbaryl	1500	(355.33) 2.55	(91.58) 74.08^{b}	(95.59) 78.59^{ab}	(91.93) 74.14^{a}
Endosulfan	400	(378.67) 2.58	(98.48) 84.68^{a}	(97.82) 82.95^{a}	(95.70) 78.19^{a}
Quinalphos	400	(363.67) 2.55	(85.17) 68.17^{b}	(88.10) 70.28^{bc}	(49.80) 45.19^{a}
Control	—	(337.67) 2.51	+(29.56) 32.83	+(20.69) 27.05	+(54.31) 47.80
SEM			2.72	3.98	2.36
CD at 5%		NS	8.15	11.92	7.09

* Log x + 2 values ** Sig–1 0.5 √X values + Percentage increase. Figures in parantheses are original values. Treatment means followed by the same alphabet are not significantly different.

TABLE 4. Effectiveness of different treatments against *Amrasca bicuttula bicuttula* Ish.

Treatments	Dose ai/ha (g)	Pre-treatment count*	% reduction in population after**		
			24 hrs	5 days	10 days
Decamethrin	10	(132.33) 2.12	(30.38) 36.69^{d}	(46.49) 43.25^{ef}	(50.09) 45.34^{de}
Cypermethrin	30	(169.67) 2.23	(52.80) 46.92^{cd}	(60.08) 51.10^{cd}	(65.87) 54.55^{c}
Fenvalerate	75	(159.00) 2.20	(52.08) 46.47^{cd}	(51.52) 46.15^{de}	(51.70) 46.25^{cde}
Fenvalerate	50	(134.00) 2.12	(36.03) 37.18^{cd}	(38.33) 38.47^{f}	(37.43) 37.78^{e}
Permethrin	75	(147.33) 2.17	(52.43) 46.68^{cd}	(57.53) 49.60^{cde}	(52.07) 46.45^{cd}
Permethrin	50	(164.33) 2.22	(44.21) 41.91^{d}	(45.68) 42.77^{ef}	(44.81) 42.27^{de}
Carbaryl	1500	(139.00) 2.14	(84.86) 67.83^{b}	(87.57) 70.23^{b}	(81.92) 65.19^{b}
Endosulfan	400	(141.67) 2.15	(97.67) 79.34^{a}	(97.13) 81.41^{a}	(94.34) 76.96^{a}
Quinalphos	400	(132.33) 2.11	(67.49) 56.04^{c}	(66.14) 54.81^{c}	(55.25) 48.33$_{c}^{d}$
Control	—	(146.67) 2.16	+(5.32) 13.16	+(9.08) 17.41	+(12.80) 20.82
SEM			3.58	2.43	2.86
CD at 5%		NS	10.72	7.27	8.56

* Log X + 2 values ** Sin–1 0.5 √X values + Percentage increase Figures in parentheses are original values. Treatment means followed by the same alphabet are not significantly different.

the synthetic pyrethroids were found to be very effective upto 10 days after spraying against the adults of ash weevil (Table 2). Fenvalerate was best against ash weevil at both the dosages tested. Endosulfan was at par with decamethrin, cypermethrin and fenvalerate (50 g ai/ha) in effectiveness after 10 days of spraying. Carbaryl and quinalphos were moderately effective against ash weevil.

Endosulfan and carbaryl were found to be the best in reducing the aphid population upto 10 days after treatment (Table 3). All the synthetic pyrethroids and quinalphos were moderately effective against aphid resulting mortality ranging between 51.4 per cent to 44.52 per cent. Permethrin (50 g ai/ha) was, however, east effective against aphid. Endosulfan was also found to be best against jassid (Table 4) and it remained effective upto 10 days after spraying. All synthetic pyrethroids and quinalphos resulted in poor jassid control even after 24 hr of treatment. Carbaryl was moderately effective against jassid.

Thus, it can be concluded that all the synthetic pyrethroids though found to be very effective against brinjal shoot and fruit borer and ash weevil adults, gave unsatisfactory control of aphid and jassid. Endosulfan and carbaryl were moderately effective against fruit borer and ash weevil but proved best for controlling aphid and jassid. KUPPUSAMY & BALASUBRAMANIAM (1980), NIMBALKAR & AJRI (1981), ABDUL ALLAM *et al.* (1980) and AZEEZ BASHA *et al.* (1982) have also reported the effectiveness of synthetic pyrethroids against brinjal fruit borer. Carbaryl has been found effective against brinjal aphid and jassid by JOSHI & SHAAMA (1973) and against jassid by MOTE (1978). Effectiveness of endosulfan (VEERAVAL & BASKARAN, 1977), endosulfan and carbaryl (DEOL *et al.*, 1978) has also been demonstrated earlier.

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BRIEF COMMUNICATION

ON ACOUSTIC CHARACTERISTICS, COMPLEXITY AND BEHAVIOUR OF *GRYLLODES SIGILLATUS* (ORTHOPTERA, GRYLLODAE)

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(Received 11 June 1983)

The paper describes the acoustic apparatus of *Gryllodes sigillatus*. Acoustic characteristics such as 'wave' 'wave packet' and 'sequence' are presented along with the physical parameters. The average values of frequency of wave, wave packet and sequence are 6500 Hz, 60 Hz and 11 Hz respectively. Acoustic behaviour of the insect in the states-caling, aggression and courtship is reported. The frequency of waves remains constant in these states. Analysis of the calling song is undertaken to explain the complexity. The song contains fundamental (6500 Hz) and overtone (12000 Hz) in which fundamental is prominent.

(Key words: acoustic apparatus, wave, wave packet, sequence, overtone)

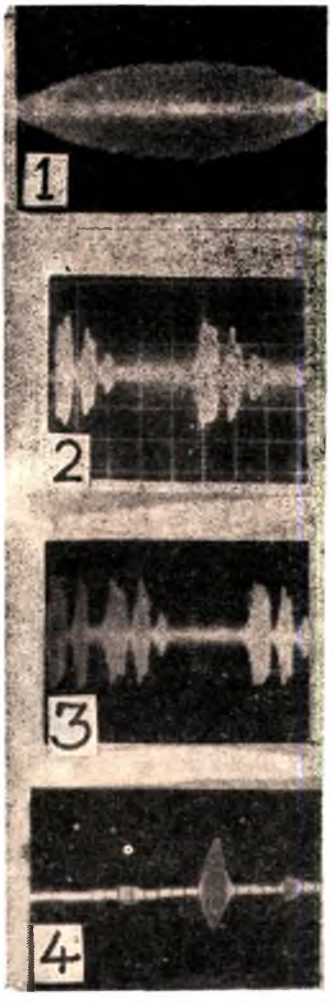
By virtue of their rythemic nature with a considerale high pitch and intensity the songs of crickets have attracted the attention of man. Taxonomists are well aware of degree of consistancy in the songs of different individuals of same species of cricket and remarkable differences in the song patterns of different species and they have used this property for the species identification. The first pbysical study of the songs of crickets was carried out by KREIDL & REGEN (1905). PIERCE (1948) studied the stridulations in *Acheta pennsylvanicus* and proposed a model for the mechanism of sound production in crickets. ALEXANDER (1957) did rigorus work on song relationship of four species of ground crickets (*Nemobius carolinus carolinus, N. confusus, N. meludius* and *N maculatus*). HUBER (1963) and HORMANN - HECK (1657) studied the aggressive and sexual behaviour of European crieckts on the basis of the physiological and genetica characters. However, the perusal of literature reveals that there exists no information on acoustic characteristics and behaviour of *Gryllodes sigillatus*. Keeping this in view authors carried out studies on the nature of sound production of this species.

The species found all over India are *Gryllodes sigillatus* and *Acheta domesticus*, among which former being more abundant. *G. sigillatus* is more common in domestic store rooms, kitchens and bath rooms.

The acoustic apparatus of male *G. sigillatus* consists of a file and a scraper. Each elytron has a thick denticulated line (file on the under surface of its cubital vein) and a relatively hard edge (scraper). The left elytron covers the right when the insect is at rest and also during the sound production. The insect

elevates its elytra at certain angle and then opens and closes at different speeds, depending upon the nature of the song. In this way the scraper of the left elytron rubs against the file of the right.

The sound produced by the insects at different states - calling, aggressive and courtship were recorded on a tape recorder (Akai 1720L) using a condenser microphone (Sony ECM-19B) and the recorded signals were fed to an oscillograph (Phillips PM 3230). The oscillagrams were photographed for the analysis (AHMED, 1978). A Sonagraph was used to understand the complexity of the insect-sound.



Figs. 1—4 Oscillograms of sound of *G. sigillatus*. 1. waves in a wave packet; 2. calling song showing wave packets and sequence; 3. aggressive song; 4. courtship song Timemark for A: 1 div. = 10 m Sec. Time mark for B, C & D: 1 div. = 1 m Sec.

Length (L) of the file; area of the elytron (a); number (N) and spacing (s) of the teeth of the file are the physical parameters of the acoustic apparatus.

TABLE 1. Physical parameters of acoustic apparatus.

Mass (gm)	a (cm^2)	L (cm)	N	S (cm)
0.254	0.38	0.136	115	0.0012
0.213	0.35	0.140	106	0.0014
0.198	0.38	0.141	112	0.0013
0.261	0.38	0.141	118	0.0013
0.269	0.37	0.133	103	0.0013
0.218	0.37	0.135	120	0.0012

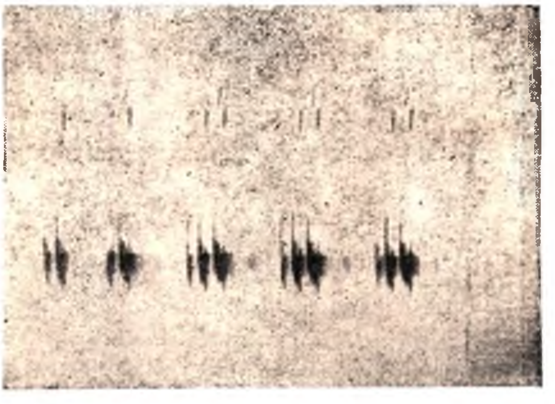


Fig. 5—Sonagram (frequency verses time) of calling song of *G. sigillatus* Wide band : 160 Hz to 1600 Hz; fundamental frequencey : 6500 Hz; overtone : 12000 Hz.

TABLE 2. Acoustic characteristics of *Gryllodes sigillatus*.

Wave packets (Pulses)								Sequence of wave packets (Chirps)			Frequency of	
Duration (msec)			Latent time (msec)		Amplitude			Duration (msec)	Latent time (msec)	Sequence (Hz)	Wave packets (Hz)	Waves (Hz)
1	2	3	1	2	1	2	3					
11.9	9.4	5.4	5.6	6.6	20.7	17.2	5.1	38.6	63.7	10	60	6280
11.8	9.2	5.1	6.0	6.3	22.1	18.1	5.3	37.8	48.4	12	62	6830
16.3	10.9	6.5	4.7	10.9	23.8	20.5	6.7	40.7	53.1	11	53	6380
10.9	8.7	5.1	5.1	6.2	20.8	15.5	4.8	36.4	44.0	12	64	6520
11 6	8.9	4.9	4.7	6.8	19.9	15.8	4.2	34.9	45.8	12	62	6320
1[illegible].6	11.4	7.2	4.3	5.8	18.1	16.9	7.0	40.4	49.1	11	57	6350

The data of these parameters for six specimen of the insect is tabulated in Table 1, reveals the consistancy in the above physical parameter in the insects.

'Waves', 'Wave packets' (Pulses) and 'Sequence of wave packets' (Chirps) (Figs. 1, 2) are considered as acoustic characteristics. The oscillagram of normal song of insects (Fig. 2) reveals that the sequence consists of three distinct wave packets. The 'Duration' and 'Latent' time of wave packets and sequences; number of wave packets in a sequence; frequency of the waves, wave packets and sequence are the acoustic parameters, are given Table 2. These parameters are affected by the physiological conditions like aggression, calling and courtship, also due to environmental influences such as temperature, pressure and humidity.

The song of insect differs only with regard to the number of wave packets in a sequence and their amplitudes. The calling, aggressive and courtship songs have same fundamental frequency (6500 ± 300 Hz). Each sequence of the calling song consists of three wave packets with decreasing amplitude and duration. The aggressive song (Fig. 3) consists of very long sequence containing many wave packets; the number of wave packets in a sequence depends upon the extent of aggression. The courtship song is differentiated from the other two patterns (aggressive and calling) by a shortening of sequence, a decrease in in sound intensity and appearance of a new element, caelld 'Intersequence' (Fig. 4).

Fig. 5 is the sonagram of the calling song of *G. sigillatus*. It can be noticed that the song consists of fundamental and overtone, the first being dominant.

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ECONOMCIS ON THE CONTROL OF SPIDERMITES ON CASSAVA

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A complex of four species of mites viz., *Eutetranychus orientalis* Klein and *Oligonychus biharensis* Hirst. (dorsum feeders) and *Tetranychus cinnabarinus* Biosd. and *T. neocaledonicus* Andre. (ventrum feeders) in India cause significant yield reduction ranging from 17 to 33 per cent. The chemicals that were found most effective for the control of mites viz., dimethoate, methyldemeton and monocrotophos @ 250 ml ai/ha were tried in larger areas to work out the economics. The cost benefit ratios were in the order of 1:6.42, 1:5.09 and 1:2.55 respectively. The efficacy of water spraying and its economics was also worked out. The cost benefit ratio was 1:2.6.

(Key words: control, spidermites, cassava)

INTRODUCTION

To control the spidermites, a total of 35 candidate pesticides were evaluated systematically through field experiments at the Central Tubercrops Research Institute, Trivandrum during 1976—1978 and many chemicals were found effective (LAL & PILLAI, 1979; PILLAI & LAL, 1980). Among these, monocrotophos, dimethoate and methyldemeton were more effective with no resurgence problem. They were, therefore, tried in larger areas to work out the economics. Besides chemical treatment, spraying the crop with water alone at 10 days interval was found equally effective against the spider mites which has been earlier established in our studies. Hence, the economics of water treatment in comparison with chemical treatment was also worked out.

Two field experiments were conducted. In the first trial three chemicals @ 150 ml ai per ha per application were evaluated in larger areas of ten cents each along with an untreated check. The first spraying was done at the onset of mite incidence (ie., January) and subsequently two times at monthly intervals. In the second field experiment spraying of water was compared with spraying of dimethoate and untreated check. Water spraying at run off levels was done at 10 day intervals and chemical spray at 30 day intervals, commencing from pesd incidence and for 90 days.

The population of spidermites were recorded from the onset of incidence at monthly intervals (ie., January to April) and the mean number of mites per leaf per month was worked out for each treatment. The yields obtained were recorded and the economics were worked out as in Tables 1 and 2. The experments were conducted using H-2304 with the reeommended package of practices of the institute.

RESULTS AND DISCUSSION

The maximum yield was recorded in methyl demeton treatment followed

Table 1. Mean population of spidermite complex per leaf per month, yield and economics of the chemical treatments against cassava spider mites.

Sl. No.	Treatments	Mean No. of mites/leaf month	Tuber yield t/ha	Market value Rs. @ 300 ton	Cost of plant protectio. (Rs)	Balance	Profit over control (Rs)	Cost benefit ratio
1.	Dimethoate	8.13	31.22	9366	260	9106	1669	1:6.42
2.	Methyl demeton	9.12	31.49	9447	330	9117	1680	1:5.09
3.	Monocrotophos	15.80	29.64	8892	409	8483	1046	1:2.55
4.	Check (untreated)	234.50	24.79	7437	—	8437	—	—

Table 2. Mean population of spidermite complex per leaf per month, field and economic of water spraying in comparison with chemical treatment for the control of spider mites..

Sl. No.	Treatments	Mean No. of mites/leaf month	Tuber yield t/ha	Market value Rs. @ 300 t	Cost of plant protection(Rs)	Balance	profit over control (Rs)	Cost benefit ratio
1.	Dimethoate	10.3	31.36	9408	260	9148	883	1:3.4
2.	Water spray	16.2	30.77	9231	270	8951	6096	1:2.6
3.	Cchck (untreated)	175.9	27.55	8267	—	8265	—	—

Notes: Cost of cultivation thas are common for the check (untreated) and treatments are not taken into account only the additional expenditures involved for plant protection are considered here.

by dimethoate and monocrotophos. Methyldemeton produced 27 percent higher tuber yield than that of control. While the yield increases in dimethoate and monocrotophos were 25.9 and 19.6 per cent respectively. The mean number of mites in the control was 234.5 per leaf per month while it was only 8-16 in the chemical treatment. The cost benefit ratio worked out on the basis of the market value of the produce and pesticides and the labour charges involved showed that dimethoate was most economical. The cost benefit ratio was found to be 1:6.42 in this case and 1:5.09 for methyldemeton.

The results of the second trial indicated that spraying water at 10 days intervals was almost equally effective as spraying chemical (dimethoate) at 30 days interval. The chemical treatment gave 13.8 per cent increased yield over control where water treatment produced 11.7 per cent yield increase. The spidermites infestation where the second trial was laid out was relatively lower (175.9 mites/leaf/month) when compared wth that of the first trial (234.5 mites/leaf/ month).

Hence the yield of the untreated control was more in the second trial. That was the reason why the yield increase in the second trial were not as significant as the yield increases obtained in the first trial. When there were 20 to 27 per cent increased yield over control in the first trial, the increases in the second trial were 11 to 14 per cent only, which showed comparatively lower infestation (Tables 1 and 2).

The actual yield difference between pesticide and water treatment was only 0.59 ton/ha indicating both were on par. However, the cost benefit ratio was higher in pesticide treatment (1:4.4) than that of water treatment (1:2.6). Spraying of water at 10 days interval required more labour involvement resulting in greater expenditure. But in regard to yield increase chemical and water tretment were on par. This method can be adopted when the labour is cheaper and pesticides are not readily available.

From the results of the two fieid experiments conducted it is concluded that for the control of spider mites on cassava, spraying the crop with dimethoate or methyl demeton is highly economical. Alternatively spraying water thoroughly on the crop at 10 days interval is equally effective as spraying with chemicals at monthly intervals.

Acknowledgement: The authors are thankful to the Director, Central Tubercrops Research Institute, Trivandrum, India for providing necessary facilities to carry out these investigations.

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CONTROL OF RICE STEM BORER *SCIRPOPHAGA INCERTULAS* WALKER WITH INSECTICIDE GRANULES*

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Field experiments were undertaken to study the use of insecticide granules applied in soil to control rice stem borer *Scirpophaga incertulas* Walker in the three usual crop seasons in Kerala. Granules of carbofuran at 0.5 kg ai/ha, mephosfolan at 1.0 kg ai/ha, and chlorodimeform at 2.0 kg ai/ha when applied at 21 and 45 days after transplantation, gave significant control of both dead hearts and white earheads in all the three crops. Quinalphos granules at 2.0 kg ai/ha gave similar control in 1st and 3rd crops. Phorate and disulfoton did not give significant results.

(*Key words:* Rice stem borer, control with insecticide granules)

INTRODUCTION

Rice stem borer *Scirpophaga incertulas* WALKER is a serious pest of paddy in Kerala, reducing the rice yield by 10-25 per cent (NAIR, 1978). Very often the application of sprays for controlling this pest is faulty giving poor control of the pest. Hence studies were made to ascertain how far insecticides would be effective in controlling the pest when used as granules. Results of these studies are presented in this paper.

MATERIALS AND METHODS

Six insecticides, carbofuran (Furadan 3G), phorate (Thimet 10 G), mephosfolan (Cytrolane 5G), disulfoton (Solvirex 5G), quinalphos (Ekalux 5G) and chlorodimeform (Galecron 5G) at two levels were used as granules (Proprietory names of the insecticides used are given in brackets). Field experiments were laid out in the farm of the College of Agriculture, Vellayani, during the three cropping seasons of *virippu, mundakan* and *puncha* of 1978—1979 using a randomized block design with 3 replications. The gross plot size was 6×4m and each plot was alternated with buffer plots of 1m width. The medium duration rice variety *Jaya* was used, planted at a spacing of 15×10 cm. Separate irrigation and drainage channels were provided for each plot to avoid interplot contamination. Cultural practices were uniform for all the treatments. Insecticide granules applied at two occasions of 21 and 45 days after transplanting, coinciding with the tillering and boot leaf stages of the crop respectively. The plots were weeded, manured and water level maintained at 2.5 cm approximately prior to the application of insecticides. The quantity of insecticide granule required for each plot was weighed out, mixed with 100 gm of dry sand to enable uniform distribution of the material in the plots and applied in the plots.

The results were assessed in terms of pest incidence in the plots under different treatments by counting the number of dead hearts in the early stage and white earheads in the later stage at weekly intervals, from two observation subplots of $1 \times \frac{1}{2}$m in each plot. For computing the data the average counts of dead hearts and white earheads per plot were taken and summation of the mean obtained at different occasions following insecticide application was calculated for each insecticide and the data were subjected to analysis of variance.

* Part of thesis submitted by the senior author in partial fulfilment for Ph.D. Degree to the Kerala Agricultural University.

RESULTS AND DISCUSSION

Results are presented in Table 1. Control of the borer in the early stage as indicated by dead heart counts was significant with all the insecticides at one or other of their doses under all the three crops. The treatments which gave control of the pest infestation in all the three crops were carbofuran at both the doses of 0.5 and 1.0 kg ai/ha, phorate at 2.0 kg ai/ha, mephosfolan at 1.0 kg ai/ha, quinalphos at 1.0 and 2.0 kg ai/ha and chlorodimeform at 2.0 kg ai/ha. Among the different insecticides, relatively carbofuran, chlorodimeform and mephosfolan were superior to the others.

As regards control of the pest nfestation leading to white earhead formation, the insecticides found significantly effective in all the three crop seasons were carbofuran, at both the doses, mephosfolan at 1.0 kg ai/ha and chlorodimeform at 2.0 kg ai/ha; quinalphos at 2.0 kg ai/ha gave significant control in the first and third crops.

It is thus observed that carbofuran at both the doses gave significant control of the pest at both the stages of the crop studied. MATHAI *et al.* (1975), JAYARAJ (1976), RAO (1977) and SUBRAMONIAN & SATHIYANANDAN (1980) had earlier reported similar results from other localities. Though phorate was repored to give significant control of the borer in Tamil Nadu (JAYARAJ *et al.*, 1976) it was ineffective in the present

TABLE 1. Mean counts per plot of rice stemborer–infested plants under different insecticide granule treatments applied and differents occasions during 3 crops.

nsecticide and dosage (kg ai/ha)		Ist crop		II crop		III crop	
		21 DAT	45 DAT	21 DAT	45 DAT	21 DAT	45 DAT
Carbofuran	0.5	19.33[a]	10.00[ab]	7.00[a]	23.33[ab]	6.33[a]	15.00[ab]
,,	1.0	14.00[a]	8.67[a]	2.67[a]	10.67[a]	2.33[a]	13.00[ab]
Phorate	1.0	26.00	22.67	13.00	70.67	8.00[ab]	28.67
,,	2.0	22.00[a]	17.00	9.67[a]	85.33	5.67[a]	21.00[ab]
Mephosfolan	0.5	24.67	16.67	12.33	27.40[b]	15.00[b]	24.67
,,	1.0	16.67[a]	14.00[b]	3.00[a]	34.23[b]	2.00[a]	20,66[ab]
Disulfoton	1.0	45.33	17.00	6.33[a]	68.67	36.33	25.33
,,	2.0	36.00	28.00	9.67	64.00	18.33[b]	24.67
Quinalphos	1.0	15.67[a]	31.33	5.80[a]	72.67	7.00[a]	41.00
,,	2.0	14.67[a]	14.00[b]	3.00[a]	56.00	20.00[b]	21.00[ab]
Chlorodimeform	1.0	25.33	19.00	4.33[a]	37.33	15.23[b]	22.33[b]
,,	2.0	14.00[a]	5.67[a]	3.67[a]	10.67[a]	10.00[ab]	12.67[a]
Control		36.00	21.50	21.00	51.17	35.00	34.83

DAT = Days after transplantion.

studies and earlier studies reported by MATHAI *et al.* (1975) and RAI & GOWDA (1976). The significant control given by mephosfolan agreed with the similar observations of RAO & DAS (1977), SAIVARAJ & VENUGOPAL (1979) and SUNDARAJ (1980). Disulfoton found ineffective in controlling the borer was earlier reported in other regions as effective by BASKARAN & NARAYANASWAMY (1975), and RAMAMURTHY *et al.* (1977). Effectiveness of quinalphos granules observed here agreed with the observation of BALASUBRAMONIAN & MICHALE (1976) and SUNDARARAJU (1980). The effectiveness of chlorodimeform in controlling the borer is in agreement with the efficacy of the insecticide against caterpillar pests reported by RAO & DAS (1977), NAIR (1978) and VELUSAMY *et al.* (1978).

From the results presented it can be concluded that protection of rice crop from stem borer damage can be obtained by the application of granules of carbofuran at 0.5 kg ai/ha, mephosfolan at 1.0 kg ai/ha or chlorodimeform at 2.0 kg ai ha twice at 21 and 45 days after transplantation.

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BRIEF COMMUNICATION

COMPARATIVE EFFICACY OF VARIOUS TREATMENTS FOR CONTROLLING POMEGRANATE FRUIT BORER, *VIRACHOLA ISOCRATES* (FABRICIUS)

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(Received 2 February 1983)

Studies conducted on comparative effectiveness of various treatments viz., bagging of fruits with different materials and spraying with different insecticides (organophosphate, carbamate and synthetic pyrethroids) against *Virachola isocrates* (Fabricius) revealed that polyethylene bagging, muslin cloth bagging and sprays of permethrin, cypermethrin (both at 0.02%), phosphamidon, monocrotophos, dimethoate, quinalphos (all at 0.05%) and dichlorvos (0.1%) were found highly effective and at par. Considering the economics of treatments three alternate sprays of phosphamidon and dimethoate (0.05%) at monthly interval are recommended.

(Key words: comparative efficacy, chemical control, pomegranate fruit borer, *Virachola isocrates)*

Pomegranate, *Punica granatum* Lin. is mainly grown in the states of Maharashtra, Gujarat, Uttar Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu. During the past few years, surveys conducted at and around Hessaraghatta and other parts of Karnataka revealed that among the insect pests attacking this crop, fruit borer, *Virachola isocrates* (Fabr.) is most serious. The larvae bore into developing fruits and feed there resulting into rotting of fruits due to secondary attack of fungi and bacteria. Previous research work on this pest is restricted to only screening of few old chemicals like DDT, endrin, phosphamidon (PATEL & TALGERI, 1956; ALAMN, 1962; AWATE *et al.*, 1977) and bagging of fruits (PRUHTI, 1969). Keeping in view the above facts present investigation has been planned to compare the effectiveness of bagging of fruits with different materials and spraying with modern insecticides including synthetic pyrethroids and work out their economics to formulate suitable viable control schedule.

Field experiments were conducted on comparative efficacy of various treatments on four year-old plants of pomegranate at the Horticultural Experiment Station, Hessaraghatta of the Indian Institute of Horticultural Research, Bangalore during 1981. There were fourteen treatments including untreated check replicated thrice in randomized block design. The treatments were permethrin, cypermethrin (both at 0.02%), monocrotophos, quinalphos, phosphamidon, dimethoate, malathion (all at (0.05%), dichlorvos (0.1%), carbaryl (0.2%) as spray and bagging with brown paper, butter paper, polyethylene (300 gauge), muslin cloth (size 20 × 15 cm). Spraying with above mentioned insecticides was started from the first week of June coinciding with fruit setting and repeated twice at monthly intervals

TABLE 1. Comparative efficacy of various treatments for controlling pomegranate fruit borer, *Virachola isocrates* (Fabricius).

Treatments	Conc. (%)	Infestation (%)	Treatment cost/ plant (Rs.)
Quinalphos (Ekalux, 25 EC)	0.05	0 (4.05)^{a}	0.70
Phosphamidon (Dimecron, 100 EC)	0.05	0 (4.05)^{a}	0.30
Dimethoate (Rogor, 30 EC)	0.05	0 (4.05)^{a}	0.47
Monocrotophos (Nuvacron, 40 EC)	0.05	0 (4.05)^{a}	0.75
Malathion (50 EC)	0.05	29.44 (33.14)^{c}	0.19
Permethrin (Permasect, 25 EC)	0.02	0 (4.05)^{a}	2.00
Cypermetrin (Cymbush, 25 EC)	0.02	0 (4.05)^{a}	2.00
Dichlorvos (Nuvan, 100 EC)	0.1	0 (4.04)^{a}	0.59
Carbaryl (Sevin, 50 WDP)	0.2	10.00 (18.22)^{b}	0.64
Brown paper bag	—	14.00 (22.26^{bc})	0.60
Polyethylene bag	—	0 (4.05)^{a}	2.00
Butter paper bag	—	11.44 (20.17)^{b}	1.30
Muslin cloth bag	—	0 (4.05)^{a}	5.00
Control (untreathd check)	—	50.00 (45.29)^{d}	—
CD 1%	—	5.1122	
CD 5%	—	3.7822	

Data are average of three replications. Figures in parenthesis are angular transformed values. Treatment means followed by same alphabet are not statistically significant.

using about 1.25 litre spray solution per tree with high volume sprayer upto full coverage of plants. Water sprayed plants served as untreated check. Simultaneously bagging with different type of materials mentioned above was also done. On an average ten fruits were bagged in each tree. All the bags were made perforated to prevent rotting of fruits. Periodically when fruits were ready for harvest, they were plucked and per cent infestation was recorded in each treatment. Data were subjected to angular transformation before statistical analysis. The cost of each treatment was also calculated.

All the treatments were significantly effective in reducing the borer infestation as compared to untreated check (Table 1). The plants treated with permethrin, cypermethrin (all at 0.02%), dichlorvos (0.1%), phosphamidon, dimethoate, monocrotophos, quinalphos (all at 0.05%) were completely free from borer attack. Among the bagging treatments, polyethylene (300 guage) and muslin cloth bagged fruits were completely free from infestation. This was followed by carbaryl (0.2%) spray treatment which recorded 10 per cent infestation and it was statistically at par with butter paper bagging (11.44%) and

brown paper (14%). The infestatson in butter paper and brown paper bagging treatments was due to the fact that bags were torn off. The highest infestation was recorded in malathion (0.05%) treated plants to the extent of 29.44 per cent as against 50 per cent in untreated check. When treatment cost was compared muslin cloth bagging was found costliest (Rs. 5/plant) and malathion (Re. 0.19/plant) spraying cheapest. Among the most effective treatments spraying with phosphamidon was found cheapest (Re. 0.30 plant) followed by dimethoate (Re. 0.47/plant), dichlorvos (Re. 0.59 / plant), quinalphos (Re. 0.70/plant) and monocrotophos (Re. 0.75/plant). Synthetic pyrethroids and polyethylene bagging were also equally effective but they were costly (Rs. 2/plant). AWATE *et al.* (1977) have recommended four sprays of phosphamidon (0.03%) for controlling this pest but in the present investigation however, only three sprays were enough to check the infestation and thus further cost of treatment is reduced. The other equally effective and cheaper insecticide dimethoate (0.5%) can also be recommended as alternate sprays to avoid resistance and resurgence of pests.

From the above study it can be concluded that in general spraying with chemicals is cheaper than bagging treatments except in case of synthetic pyrethroids. Synthetic pyrethroids although were equally effective, were costly hence they cannot be recommended. Bagging can be practiced only in a limited area. Study suggests that alternate sprays of 0.05% phosphamidon and dimethoate can be recommended for its effective and economic control.

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Entomon, 1983, *Vol* 8, *No*. 4, *pp*. 385 *to* 387

BRIEF COMMUNICATION

BRUCHIDIUS PYGOQUADRIMACULATUS SP. NOV. ON *ALBIZZIA SP.* (COLEOPTERA: BRUCHIDAE)

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(*Received 28 February 1983*)

Bruchidius pygoquadrimaculatus sp. nov. is described from Mysore (India) zoo area, collected from seeds of *Albizzia* sp.

(*Key words:* new species; *Bruchidius; Albizzia* sp.)

Bruchidius Schilsky (1905) family Bruchidae is the chief representative in collections on bruchids from India as the records show. Arora has published an account of 23 spp. (Arora, 1977) whereas, Singh & Saini (1978) and Zampetti (1979) added one species each to the existing number. The majority of species attack the host plants belonging to family Leguminosae and the present species has too been collected from the seeds of *Albizzia* sp.

Bruchidius pygoquadrimaculatus sp. nov. (Figs. 1—6.)

Head dark brown, broad, emarginate behind the eyes, frons strongly carinate, surface provided with dirty white setae. Eyes emarginate, bulging, canthus deep, more than half the length of the eye, provided with dirty white setae. Antennae short not surpassing the base of pronotum, subserrate, yellowish, 5th to 7th segments margined black.

Prothorax dark brown, subconical, produced into acute postero-lateral angles, median posterior bulge also present, its surface punctured and provided with dirtywhite and blackish setae, the former arranged to form an inverted 'T', two small spots of whitish setae, one on either side of middorsal line also present.

Scutellum squarish, bifid posteriorly, its surface provided with dirty white setae. Elytra blackish brown, together longer than broad, but not covering the last one abdominal tergite, callus slight, a pair of tubercles present at the base of 3rd and 4th striae of each elytron, striae 4th and 5th stopping short of others, surface covered over by dirty white and blackish setae, the former arranged more or less in the form of a saddle. Legs testaceous with tips of tarsi black, hind femur bicarinate below, inner carina provided with a preapical tooth. Pygidium oblique, longer than broad and provided with dirty white and blackish setae, the latter arranged into four spots.

Phallus length 0.92 mm; parameres fused at their bases upto 1/10th of their total length, sclerotized along their outer borders, tips more or less spoon-shaped, provided with 11-12 long setae; exophallus, a broad tube produced into processes at their lateral ends; exophallic valve broadly conical, provided with paired pits and minute sensory setae present towards the distal tip; endophallus provided with weekly sclerotized

* For correspondense

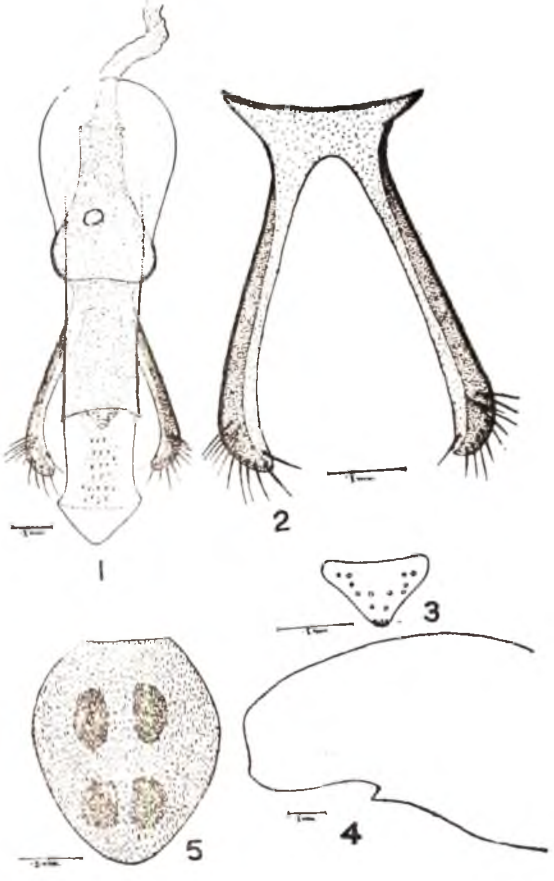

Fig. 1—Male genitalia; 2—Magnified parameres; 3—Exophallic valve; 4—Hind femur showing the dent on the inner carina; 5—Pygidium with four spots.

tubercles and a ring behind; saccus more and so naked.

Measurements: Length male 5.00 mm

Material: **Holotype** ♂, only one specimen collected from the seeds of *Albizzia* sp. from Mysore Zoo area, during January, 1982. Deposited in the museum of Department of Zoology, Punjabi University, Patiala. **Index** No. 105/82.

Remarks: The species is closely related to *Bruchidius albizziae* Arora, but it differs in the colour of setae as the latter are pale to golden in *B. albizziae* and, dirty white and blackish in the present case. In the former species, also the parameres are finger-shaped and the valve is truncated. Also, the scutellum is bifid posteriorly and there are four distinct spots in *B. pygoquadrimaculatus* sp. nov.

Acknowledgements: The authors are thankful to Dr. Sarbjit Singh Grewal for taking the photographs.

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BRIEF COMMUNICATION

SIMULATION OF INSECT TRACHEAL PATTERN WITH SOME PHOSPHOLIPIDS

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(*Received 3 March 1983*)

Some phospholipids tend ro simulate insect tracheal taenidal pattern under certain experimental conditions.

(*Key words:* phospholipids, taenidial pattern)

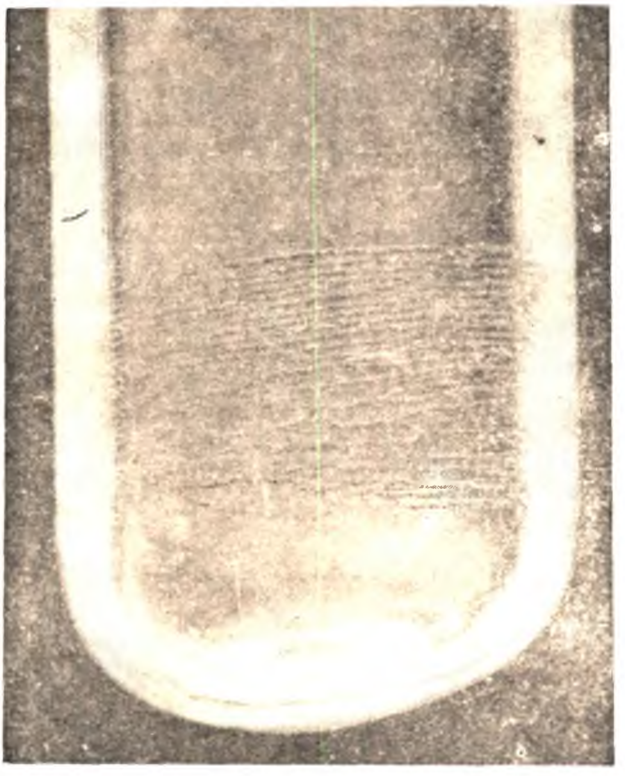

Fig. 1. Simulated trachael pattern obtained with pure lecithin.

Existing literature related to the insect respiratory system does not explain the basic physical properties of trachae and/ or trachaeoles. It is not known as to why trachaete arthropods poses monotonous consistency, helical or spiral

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thickenings called taenidia in their tracheal lumen. LOCKE (1964) has suggested as to how they may have developed by buckling, but very few studies are really available to substantiate his speculation. However, some evidence indicating the abrasive role of air in the information of tracheal patterns has been put forth (TONAPI, 1968; 1971).

While studying the interaction of certain lipases with some lipids it was noticed that some phospholipids tend to simulate trachael taenidial pattern under experimental conditions. Fig. 1 presents one such pattern obtained with pure lecithin. A mixture of 5 m mole lecithin (as per the inorgnic phospher content) and 2.5 ml chloroform was held in a water jacket and was slowly evaporated. This left behind the typical wavy pattern of trachael taenidia.

Physico-chemical investigations of insect tracheae have alreday indicated the importance of phospholipids being the major components of the tracheal constitution (RICHARDS, 1951). They being the most labile constituent, the suggestions such as a simple physical force (WIGGLESWORTH, 1965) in the form of with-drawal of fluid (LOCKE, 1964) seems to be quite sufficient for the production of taenidial formations. Exactly similar force operates in simulated experiments when volatile chloroform withdraws from its mixture with the lecithin.

Similar pattern formation was observed when another phospholipid-cephalin was used. Mixture of these two in different concentrations produced different results. Certain phospholipids such as phosphotidylethyleneglycol and phosphotidylinositol failed to simulate the above indicated pattern.

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BRIEF COMMUNICATION

NEW HOST RECORDS OF SOME PARASITES AND (PREDATORS OF APHIDS HOMOPTERA : APHIDIDAE) FROM INDIA

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(Received 25 September 1982)

Six species of aphids have been recorded as new host records for 3 species of parasites and 6 species of predators from India.

(*Key words:* new aphid host records of parasites and predators)

In a recent exploration of aphids and aphidophagous insects in some parts of the Tripura State, North-Eastern State, 6 species of aphids have been found as new host records for 3 species of parasites and 6 species of predators. Two of the parasite species belong to the family Aphidiidae and one species to the family Aphelinidae (Hymenoptera). Six species of predators include 1 species of family Syrphidae (Diptera), 3 species of family Coccinellidae (Coleoptera) and 2 species of family Hemerobiidae (Neuroptera). Previous to this 76 species of aphidiid parasitizing 64 aphid species, 11 species of aphelinids parasitizing 12 species of aphids, 32 species of syrphids feeding on 23 species of aphids, 72 species of coccinellid predating on 57 species of aphids and 3 species of hemerobiids preying on 9 species of aphids were known from India (Agarwala *et al.* 1981; Agarwala *et al.*, in press, Raychaudhuri, in press).

All the reported material were collected from localities in and around of Agartala during November 1981—May 1982.

Materials of the reported species are in the collection of the first author.

Host species	Parasite species
Ceratovacuna silvestri (Takanashi)	*Trioxys indicus* Subba Rao & Sharma
Pentalonia nigronervosa Coquerel	*Aphelinus* sp.
Toxoptera aurantii (Boyer)	*Lysiphlebus delhiensis* (Subba Rao & Sharma)
Aphis nasturtii Kaltenbach	*Paragus serratus* (Fab.)
Ceratovacuna silvestri (Takahashi)	*Anisolemnia dilatata* Fab.
	Eumicromus sp.
Cervaphis schouteniae Goot	*Scymus* sp.
Greenideoidea ceyloniae Goot	*Menochilus sexmaculata* Fab.
	Micromus timidus Hagen

Acknowledgements: Thanks are due to P. Stary Czechoslovakia and A. P. Kapur, Calcutta for their helpful comments on the identity of parasites and predators respectively.

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BRIEF COMMUNICATION

STUDIES ON THE HOST-AGE SELECTION BY *ECHTHROMORPHA AGRESTORIA NOTULATORIA* (FAB.) A PARASITOID OF *MYTHIMNA SEPARATA* WALK

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(Received 31 August 1982)

The present studies were carried out by providing 0—9 day old host pupae of *mythimna separata* Walk. to the parasitoid *Echthromorpha agrestoria notulatoria*. Maximum (37) parasitoids emerged from 2—3 day old host pupae with 37% parasitism. The age of host pupae could be significantly correlated with percentage of parasitism ($p<9.05$).

(*Key words: echthromorpha agrestoria notulatoria*, host-age selection)

Various stimuli of hosts such as shape, size, movement and colour aid entomophagous parasitoids for finding their hosts (VINSON, 1976). Host's size or age as a criterion for selection by parasitoids has been studied using *Campoletis haywardi* Blanchard (LEONG & OATMAN 1968), *Campoletis chlorideae* Uchida (LINGREN *et al.*, 1970), *Temelucha* sp. (OATMAN & PLATNER, 1974) and *Campoletis sonorensis* Cameron (SCHMIDT, 1974).

The present study was undertaken in the Laboratory (26 ± 1°C, 50–55% R. H. and 12 h daily photoperiod) and replicated five times by providing 20 host pupae of different age groups to mated female parasitoids. Each lot of host pupae was kept into separate containers and daily emergence of adults was recorded. The percentage of parasitism was determined and its relationship with host age was examined by regression analysis.

The data revealed that 12, 24, 37, 31, 18, 9, 5 and 3 parasitoids (with the same percentage values) emerged from 0–1, 1—2, 2—3, 3—4, 4—5, 5—6, 6—7, and 7—8 day old host pupae. Maximum parasitism 37% was recorded on 2—3 day old host pupae and no parasitoids emerged from 8—9 day old host. There exists a significant ($P < 0.05$) correlation between the host age and percentage of parasitism ($r = -0.6105$).

LINGREN *et al.* (1970) studied host age preference of *C. chlorideae* (Uchida) for parasitism towards army worms *Pseudolatia separata* (Haworth), *Trichoplusia ni* (Hubn.), *Prodenia eridinia* and *P. praefica* Grote, 1—8 day old larvae of these hosts were readily parasitized and 2—4 day being most acceptable. In the present findings 1—7 day old pupae were acceptable, 1—6 day old readily parasitized and 2—3 day old being most suitable. LEONG & OATMAN (1968) subjected 50 host larvae of *P. operculata* to *C. haywardi* which yielded higher average number of 13.9 of adults and OATMAN & PLATNER (1974) noted that 3—4 day old larvae of *Pthorimaea opercuellla* (Zeller) were more suitable for maximum adult emergence of *Temelacha* sp. In our studies 2—3 day old pupae appear to be more

suitable which produced 37%, the maximum adult parasitoids and 8—9 day old pupae remained non-parasitized. These results are also in agreement with that of SCHMIDT (1974) wherein 3—5 day old larvae of *Heliothis zea* (Boddie) were prefered by *C. chlorideae.*

Acknowledgements: The Authors are thankful to Prof. R. NAGABHUSHANAM, Head Department of Zyology, Marathwada University, Aurangabad for laboratory facilities and to CSIR, New Delhi for financial support.

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BRIEF COMMUNICATION

RESIDUAL TOXICITY OF CERTAIN INSECTICIDES TO GRAPEVINE FLEA BEETLE

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Studies on chemical control of the grapevine flea beetle *Sealodonta strigicollis* showed that both monocrotophos (0.05%) and carbaryl (0.15%) had good initial toxicity for four days causing 90% mortality. Carbaryl (0.15%) showed residual toxicity for 32 days after spraying, which was closely followed by monocrotophos (0.05%) with residual toxicity for 33 days.

(Key words: chemical control, grapevine flea beetle).

The grapevine flea beetle, *Scelodonta strigicollis* (Mots.) is a pest of all the grape growing regions in the country and occupies an important position both from the point of regularity of occurrence and severity of damage caused. The adults appear in large numbers about the time of pruning and feed on the newly emerged flush. Information on the efficacy of commonly used insecticides against this pest is scanty and needs further studies.

The experiment was conducted in green house of Entomology Department, College of Agriculture, Rajendranagar, Hyderabad during 1981. Rooted cuttings of grapevine of *Anab-e-shahi* variety were raised in earthen pots of 30 cm dia. Twenty pots were used representing five treatments including check and each replicated four times. The commercial formulation of insecticides were tested at recommended concentrations viz., moncrotophos 0.05%, quinalphos 0.05%, phosalone 0.07% and carbaryl 0.15%. The potted plants of each treatment were sprayed with the respective insecticide using graduated glass atomizer giving uniform and thorough coverage of the foliage. Each plant required 10.0 ± 0.5 ml. of the spray fluid depending on the foliage. For each replication ten flea beetles starved for 24 hours were released. The insects were confined to treated plant by covering the plant with muslin cloth bag and tied to the rim of the pot. The cloth bag was kept in position by means of bamboo pegs. Data on the mortality of the released beetles were recorded on succeeding day. All the beetles, both live and dead, were removed and a fresh batch of ten beetles was released in each pot. The experiment was thus continued till there was no mortality for three days consecutively. The data recorded were subjected to probit analysis (FINNEY, 1952). PT values were also calculated (Saini, 1959; PRADHAN & VENKATARAMAN, 1962).

Both monocrotophos 0.05% and carbaryl 0.15% appeared to have good initial toxicity (Table 1 & 2) exercising more than 90% mortality of flea beetle for four days. Carbaryl 0.15% showed

TABLE 1. Residual toxicity of certain insecticidal treatments to grapevine flea beetle (PT values).

Insecticidal treatment	No of days for which more than 90% mortality recorded	No. of days for which mortality observed (P)	Mean mortality (T)	Product of toxicity (PT)
Monocrotophos 0.05%	4	33	39.53	1304.5
Quinalphos 0.05%	1	17	61.87	1051.8
Phosalone 0.07%	—	25	39.58	989.50
Carbaryl 0.15%	4	32	48.68	1557.8

TABLE 2. Residual toxicity of certain insecticidal treatments against grapevine flea beetle (LT 50 values).

Insecticidal treatment	Heterogenity	Regression equation	LT 50 valuet (days)	Fiducial limits (days)
Monocrotophos 0.05%	$x^2 = 1.3754$	$y = 20.663 - 5.078x$	12.14	11.26–13.11
Quinalphos 0.05%	$x^2 = 0.1248$	$y - 36.740 - 10.313x$	11.96	10.45–12.48
Phosalone 0.07%	$x^2 = 0.1368$	$y = 25.676 - 6.810x$	10.86	10.24–11.53
Carbaryl 0.15%	$x^2 = 0.2128$	$y = 42.665 - 11.729x$	16.28	15.78–16.79

residual toxicity for 32 days after spraying. Its prolonged residual toxicity for was also evident from high values of IT 50 and PT index of 16.28 days and 1557.8 respectively. It was closely followed by monocrotophos 0.05% which gave mortality of the pest for 33 days. The IT 50 and PT values of it were 12.14 days and 1304.5 respectively.

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STUDIES ON POPULATION DYNAMICS OF CITRUS LEAF-MINER *PHYLLOCNISTIS CITRELLA* STAINTON (LEPIDOPTERA: PHYLLOCNISTIDAE)

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(Received 22 May 1983)

Studies on population dynamics at Central Horticultural Experiment Station, Chethalli, Kodagu over three years (1979 to 1982) revealed that the citrus leaf miner was active throughout the year with four peaks of population (more than 10% incidence) on *Coorg mandarin* and nine peaks (more than 50% incidence) on *Rangpur* lime with 13 overlapping generations per year. Availability of tender flush appeared to be the governing factor for the pest incidence and the climatic factors did not have any impact. The crucial period for taking up the insecticidal spray would be 7-10 days earlier to the occurrence of peak population on *Coorg mandarin* i.e., third to last week of October, second to third week of April, fourth to last week of May and third to fourth week of June.

(Key words: citrus leaf-miner, population dynamics, *Coorg mandarian* and *Rangpur* lime)

INTRODUCTION

The citrus leaf-miner, *Phyllocnistis citrella* Stainton is regarded as a serious pest among the Lepidopterous insect pests of citrus (BUTANI, 1979). RAHMAN & YUNUS (1945) reported that citrus leaf-miner adult resumed its activity in February, reached peak once in March to May and again in September to November and lowest during December—February. In Uttar Pradesh the larvae and pupae were observed during winter months under field conditions by PANDEY & PANDEY (1964). These authors further reported that activity of this pest increased from August to November and declined as winter progressed. The activity resumed in February—March and then declined gradually with commencement of summer. According to KHANNA & PANDEY (1966) heavy infestations of this pest were observed from July to October and February to March with 6 generations. In Punjab this pest poses a serious threat to tender foliage of citrus during March-May and August—October when there is maximum new growth (BATRA & SANDHU, 1981). Since detailed information about the seasonal incidence of this pest under Kodagu conditions was not available, an attempt has been made for studying the population dynamics of citrus leaf-miner.

MATERIALS AND METHODS

The preliminary studies by SINGH & RAO (1978) on the relative incidence of citrus leaf-miner on different citrus varieties/species indicated that *Rangpur* lime was the most susceptible variety as it produced tender flushes throughout the year. To know the maximum number of generations of citrus leaf-miner, *Rangpur* lime variety was selected along with

a commercial variety *Coorg mandarin* for population dynamics studies of this pest.

Seasonal incidence and population dynamics of citrus leaf-miner, on *Coorg mandarin* and *Rangpur* lime was studied on 20 and 6 plants respectively. These plants were randomly selected and tagged. Ten flushes (with at least 6 opened tender leaves) per plant in case of *Coorg mandarin* and 20 flushes per plant in case of *Rangpur* lime were examined at random during each observation. Observations were made from July 1979 to June 1982 at weekly intervals. On each flush, total number of leaves, total number of infested leaves, total number of small (less than 2 mm), medium (2–4mm) and full grown (more than 4 mm) larvae and pupae were counted and recorded. Meteorological data for the entire period has been averaged and depicted in Fig. 3.

RESULTS AND DISCUSSION

The results of seasonal incidence studies of citrus leaf-miner on *Coorg mandarin* and *Rangpur* lime for three years has been averaged and depicted in Fig. 1. It is clear from these studies that citrus leaf-miner was present on the crop throughout the year. On an average the degree of infestation ranged from 0.9 to 29.2 per cent during July 1979 to June 1982. The pest was very active (more than 10 per cent incidence) during 27th and 28th week (July first and second week), 30th week (July last week), 44th to first week (November first to January first week), 17th and 18th week (April last to May first week) and 23rd to 26th week (June first to last week). The observation made on the number of small larvae (indication of next generation) revealed that in all, there were 13 peaks of highest larval count indicating 13 overlapping generations.

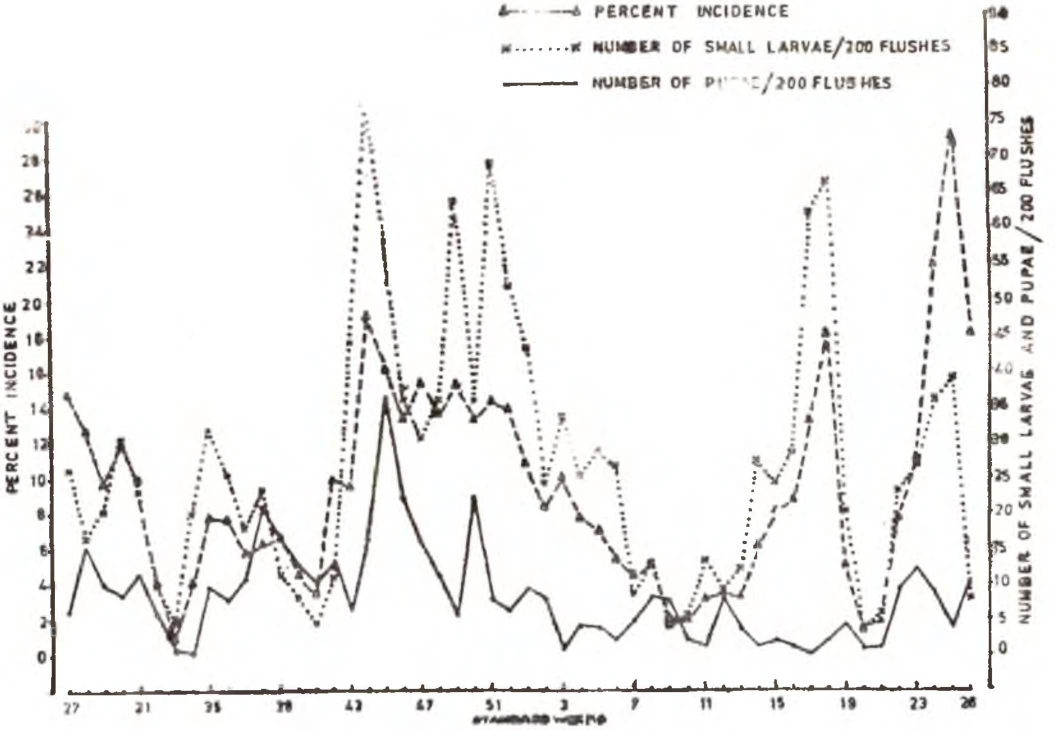

Fig. 1. Seasonal incidence of citrus leaf-miner *Phyllocnistis citrella* Stainton on *Coorg mandarin*.

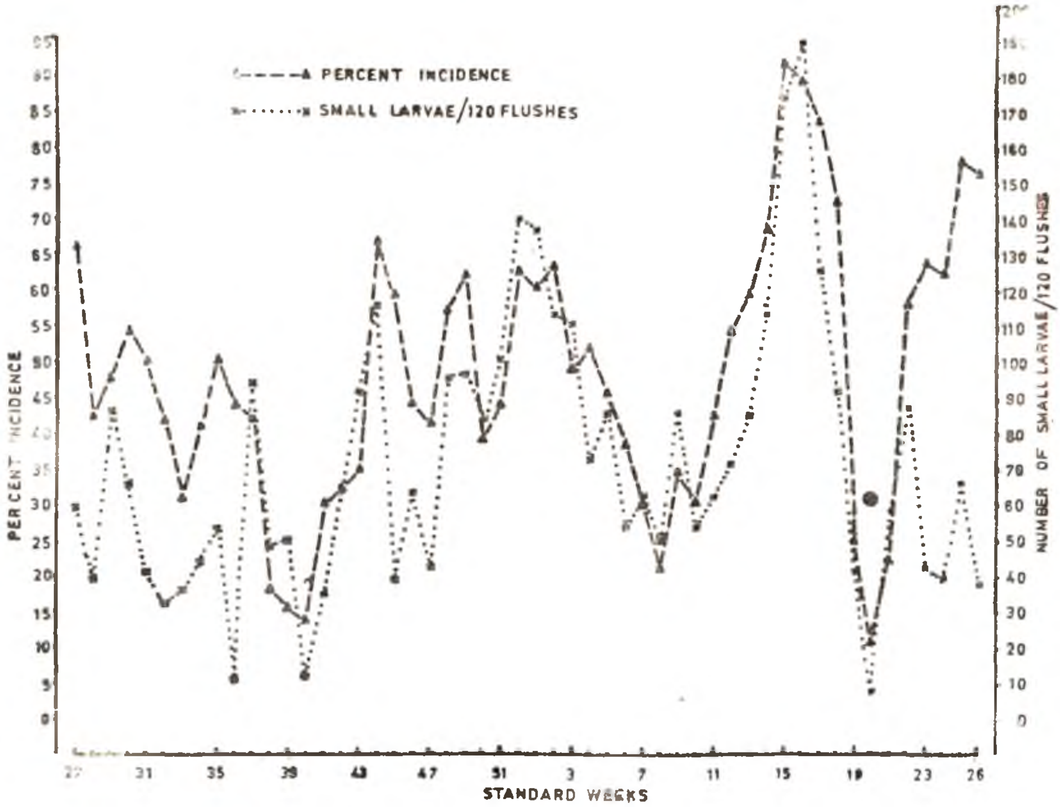

Fig. 2. Seasonal incidence of citrus leaf-miner *Phyllocnistis citrella* on *Rangpur* lime.

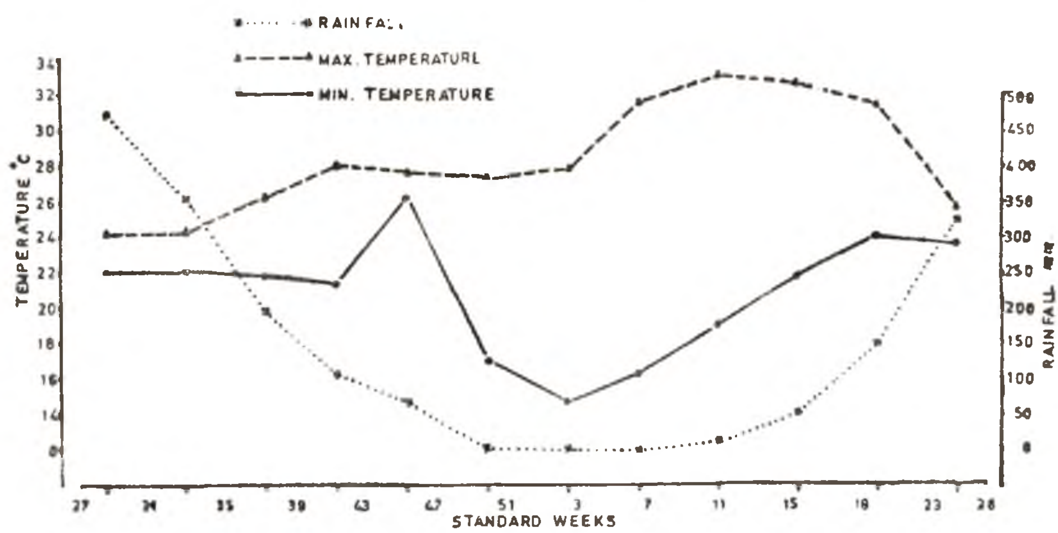

Fig. 3. Meterological data.

On *Rangpur* lime, the citrus leaf-miner incidence ranged from 11.0 to 91.8 per cent (Fig. 2). On an average more than 50 per cent incidence of this pest was recorded during 27th week (July first week), 30th and 31st week (July last week and August first week) 35th week (August last week), 44—45th week (November first and second week), 48—49th week (December first and second week) 52th to 2nd week (December last week to January second week), 4th week (January last week), 12—18th week (March fourth to May first week) and 22—26th week (May last week to June last week). The observation on the total number of small larvae revealed 13 overlapping generations in a year. The climatic conditions however may not directly influence the citrus leaf-miner population but probably effect through influencing the availability of tender leaves (new growth).

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REPORTS AND NEW RECORDS

CYNODON DACTYLON, A NON-HOST OF RICE GALL MIDGE

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(Received 31 December 1982)

Studies based on cross infestation and pupal morphology appears to suggest *Cynodon* midge to be different from the one which infests rice

(Key words: rice gall midge, host range).

A large number of weeds including *Cynodon dactylon* are reported as alternate hosts of rice gall midge *Orseolia oryzae* W. M. (YEN *et al.* 1941; REDDY, 1967; ISRAEL, *et al.* 1970).

The rice (T (N) 1) and *Cynodon* midges were reared separately in the laboratory and cross infestation studies made as per method described by NATARAJAN *et al.* (1981) with four replications.

In both the cases there was no host preference for egg laying, but after hatching, the larvae were unable to produce galls on the other plant species. Pupal length of rice gall midge (average 7.14 mm) was higher than *Cynodon* midge (average 6.03 mm). The thorax size was more (2.7 × 1.62 mm) in the latter case as compared to the former (1.89 × 1.23 mm). The mean abdomen size in rice gall midge was 4.05 × 1.36 mm while in *Cynodon* midge it was 3.74 × 1.24 mm. The cephalic horns had unequal terminal spines in the *Cynodon* midge puparium and equal spines in rice midge puparium.

It thus appeared that the two midges were different species. The *Cynodon* midge was identified as *Orseolia* Spp. by Dr. S. N. RAO of Marathawada University and Commonwealth Institute of Entomology, London.

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REPORTS AND NEW RECORDS

ANOMALA NAINITALII (COLEOPTERA : SCARABAEIDAE—RUTELINAE) A NEW SPECIES FROM NAINITAL

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(Received 2 February 1983)

During the survey of the insect fauna of Nainital a large number of Scarabaeids which damage fruit trees were collected. Among them a new species was collected from Naini Tal and is described.

(Key words: Anomala nainital, Scarabaeidae, Rutelinae).

A number of species have so far been described under *Anomala* Samo. The present species, *A. nainitalii* sp. nov. have been collected from shrubs near Raj-Bhawan area, Nainital.

The **holotype** is in the collection of the Entomology Laborato.., Department of Zoology, Kumaun University, Nainital.

Anomala nainitalii

Male: Colour shining green above and black beneath; legs, clypeal, pronotal and elytral margin brown and smooth. Head punctured, eyes large, antennae nine which five segments segmented, first segment elongated, next five segments are of similar size and rest and three form the club. Pronotum densely punctured and impunctate in the middle which form a longitudinal line. A band of golden brown hairs between the scutellum and pronotum is present; scutellum large, rounded at the base and impunctate. Elytra punctured, thus forming a beautiful sculpture on itself; humeral callus impunctate. Pygidium rounded and impunctate.

Underside: Black with thick hairs on the sternum and scanty on the abdomen.

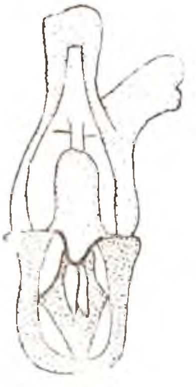

FIG 1

FIG.2

Fig. 1. Anomala nainitalii (Natural size)
Fig. 2. Male genilalia-Front view (20×)

Male genitalia: Phallobase bifurcated, median lobe large, parameres bilobed and attached to the median lobe.

Legs: Long slender, fore and hind femur without teeth and spine on the outer side, while middle femur with one terminal tooth and spine.

Size: Length 20 mm. Breadth 8 mm.

Female: Unknown.

Holotype Male collc. L. Gangola INDIA Nainital. (Kumaun) 25 v.1976.

A. nainitalii sp. nov. resembles closely *A. xanthoptera* Arrow, but can be distinguished by the following characters:

A. xanthoptera Arrow is yellow green with ventral abdominal segments black and rest of the parts brown, humeral callus of elytra punctate, front tips with strong teeth while these characters are absent in the *A.* nainitalii sp. nov. In *A.* nainitalii ventral abdominal segment is black with golden hairs. Median lobe is absent in *A. xanthoptera* Arrow.

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